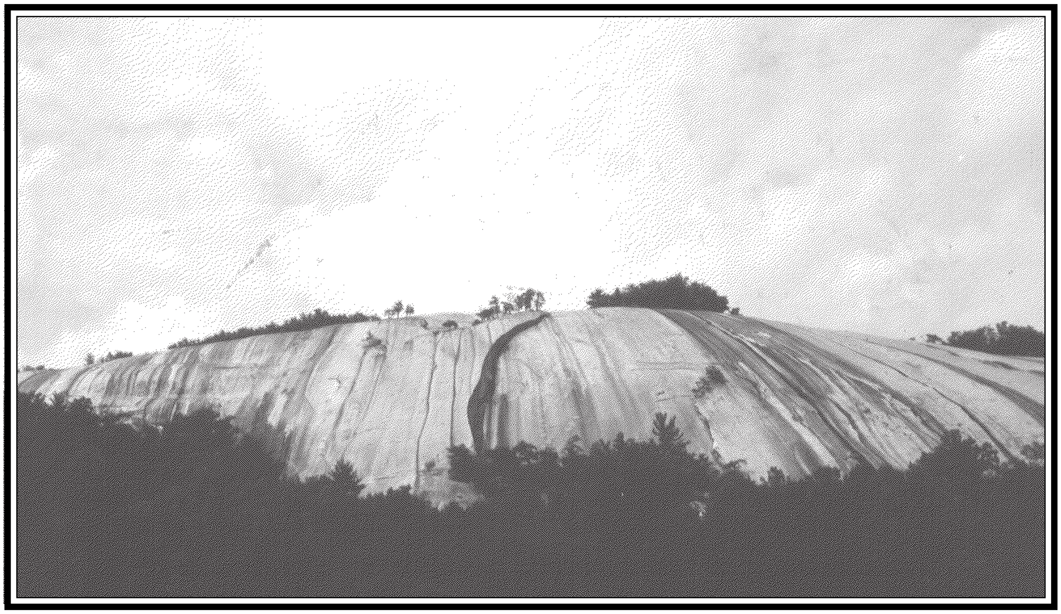
OUR



CHANGING

LAND

Stone Mountain State Park

An Environmental Education Learning Experience

Designed for Grades 4-8

"The face of places,
and their forms decay;
And what is solid earth,
that once was sea;
Seas, in their turn,
retreating from the shore,
Make solid land,
what ocean was before."

- Ovid
Metamorphoses, XV

"The earth is not finished,
but is now being, and will
forevermore be remade."

- C.R. Van Hise
Renowned geologist, 1898

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This Environmental Education Learning Experience
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N.C. Division of Parks and Recreation
Department of Environment and Natural Resources

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The N.C. Department of Public Instruction;

The N.C. Department of Environment and Natural Resources;

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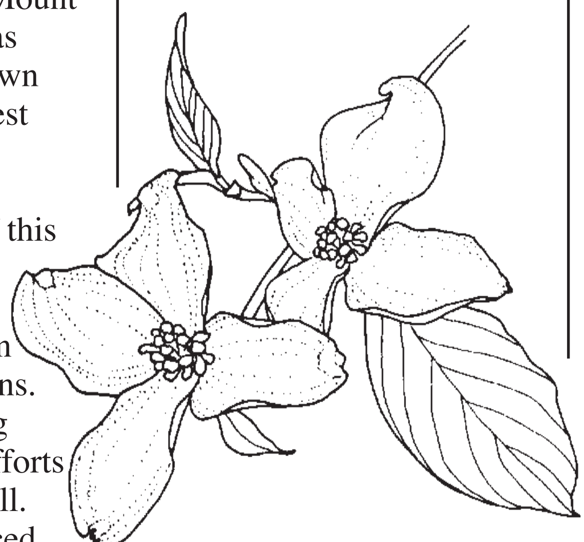
Introduction to the North Carolina State Parks System

Preserving and protecting North Carolina's natural resources is actually a relatively new idea. The seeds of the conservation movement were planted early in the 20th century when citizens were alerted to the devastation of Mount Mitchell. Logging was destroying a well-known landmark — the highest peak east of the Mississippi. As the magnificent forests of this mile-high peak fell to the lumbermen's axe, alarmed citizens began to voice their objections. Governor Locke Craig joined them in their efforts to save Mount Mitchell. Together they convinced the legislature to pass a bill establishing Mount Mitchell as the first state park of North Carolina. That was in 1915.

The North Carolina State Parks System has now been established for more than three quarters of a century. What started out as one small plot of public land has grown into 61 properties across the state, including parks,



recreation areas, trails, rivers, lakes and natural areas. This vast network of land boasts some of the most beautiful scenery in the world and offers endless recreation opportunities. But our state parks system offers much more than scenery and recreation. Our lands and waters contain unique and valuable archaeological, geological and biological resources that are important parts of our natural heritage.

As one of North Carolina's principal conservation agencies, the Division of Parks and Recreation is responsible for the more than 168,000 acres that make up our state parks system. The division manages these resources for the safe enjoyment of the public and protects and preserves them as a part of the heritage we will pass on to generations to come.

An important component of our stewardship of these lands is education. Through our interpretation and environmental education services, the Division of Parks and Recreation strives to offer enlightening programs that lead to an understanding and appreciation of our natural resources. The goal of our environmental education program is to generate an awareness in all individuals that cultivates responsible stewardship of the earth.

For more information contact:

N.C. Division of Parks and Recreation
1615 Mail Service Center
Raleigh, NC 27699-1615
919/ 733-4181
www.ncsparks.net

Introduction to Stone Mountain State Park

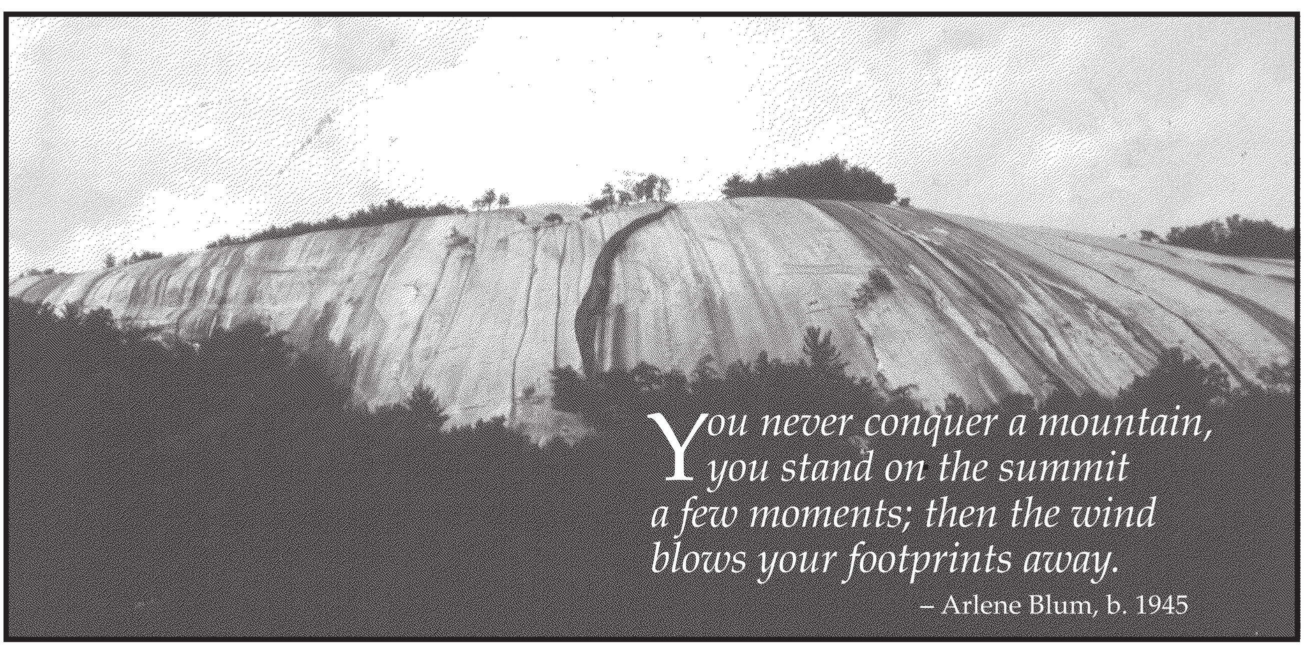
Stone Mountain State Park is located on the eastern edge of the Blue Ridge Mountains in North Carolina. The park lies in the extreme northern portion of Wilkes County and extends into the southeastern part of Alleghany County. Stone Mountain is the second largest state park in North Carolina, consisting of approximately 14,000 acres.

The most prominent feature of the park is Stone Mountain itself. This large outcrop of granodiorite rock is a unique geological feature and is the largest exfoliation dome in North Carolina. Stone Mountain rises more than 2,200 feet above sea level. Its crest is almost 700 feet above the surrounding terrain of old fields, mixed forests, clear streams and waterfalls. Stone Mountain Falls, the largest waterfall in the park, is a cascade of over 200 feet. There are other granodiorite outcrops and waterfalls that are accessible via the park's 15 miles of hiking trails. At Stone Mountain State Park, students can see and learn about some of the geologic processes that continue to shape our land.

The Park as an Outdoor Classroom:

State parks are not only wonderful places for recreation, but also for studying earth science, ecology, environmental issues, biology, conservation, social studies, literature and mathematics. Although the primary interpretive theme for Stone Mountain State Park involves geology, other topics can be explored here as well. These include plant communities, water quality, mountain culture, and the literature of nature writers such as Thoreau, Emerson, Leopold and Muir. At the park, students can learn on a hands-on basis.

Groups are encouraged to visit the park during all seasons of the year for hikes, exploration, nature study and other activities. Leaders may choose to design and conduct their own activities or make use of the park's environmental education activity packets. A park ranger would be happy to meet with your group to answer any questions the students may have, or welcome the group and present a short talk. Every effort will be made to accommodate persons with physical disabilities. Please contact the park office at least two weeks in advance to make arrangements for a group visit.



Park Facilities:

Restrooms: Restrooms are available at the park visitor center, the picnic area and the parking area for Stone Mountain.

Picnic Area: A 75-site picnic area with tables, grills, restrooms, a water fountain and three picnic shelters is located across the road from the park office. The shelters may be reserved through the visitor center for a fee.

Cultural History Sites:

Mountain Culture Exhibit: Located at the visitor center, a mountain culture exhibit tells the story of how the independent mountain settlers provided shelter, food and clothing for their families. A loom, spinning wheels, hunting and fishing displays, a copper still, old photographs and tools, and other antiques tell the story of these independent, hardworking individuals.

Hutchinson Homestead: The Hutchinson Homestead – complete with log cabin, barn, blacksmith shop, corncrib, and meathouse – is a mountain farm built in the mid-19th century by John and Sidney Brown Hutchinson. Restored in 1998, the homestead is representative of the lives of the early settlers of the Stone Mountain area. Original furnishings and other antiques, displays, and audio stories take visitors back to a way of life nearly extinct.

Visitors to the homestead should park at the Stone Mountain parking area and hike a 1/2-mile trail to the site.

Garden Creek Church: This old church is located on the bank of the East Prong of the Roaring River. The church, established in 1897, is one of the few original churches in Wilkes County that has not undergone any major repairs or remodeling. Gradually, members died or moved away and attendance fell sharply. When Nora Warren Gilliam, the last surviving member of the church, died on June 29, 1986, Garden Creek ceased to exist as an organized church.

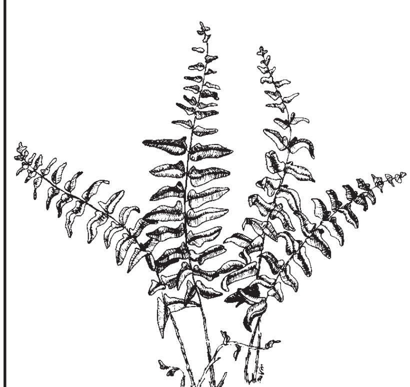
Recreation:

Another facet of state parks is outdoor recreation, such as rock climbing, hiking, camping, fishing, and horseback riding. By preserving and protecting North Carolina's unique natural features, state parks provide high quality outdoor recreation in beautiful surroundings.

Family Camping: Family camping is available year-round on a first-come basis. A modest fee is charged. Each of the campsites has a grill, picnic table and gravel pad for tents or RVs. A dump station is available for self-contained units. A centrally located washhouse provides drinking water, hot showers and toilet facilities. This washhouse is closed during the winter. Contact the park office for information on electric hookups.

Group Camping: Four primitive campsites are available for organized groups. A small fee is charged for these sites, which are available by reservation only. Each site has a grill and picnic table. Dumpsters are located nearby. A pit toilet is also available. Drinking water must be carried to this area.

Back Country Camping: Six backpack campsites are located along Widow's Creek. The trail leading to the sites is one mile past the paved parking lot. Campers must walk 1.5 to 3 miles to the site depending on which site is available. All supplies must be packed to the camping area except water, which is available a short distance from each site. Backpack camping is on a first-come basis by permit only. Campers should register at the back country camping parking lot. A maximum of four people is permitted on each campsite. Please carry out your trash; there is no trash disposal at the campsite.



Scheduling a Trip:

1. To make a reservation, contact the park at least two weeks in advance.

2. Complete the scheduling worksheet, located on page 8.1, and return it to the park as soon as possible.

Before the Trip:

1. Complete the pre-visit activities in this Environmental Education Learning Experience.

2. The group leader should visit the park without the participants prior to the group trip. This will enable you to become familiar with the facilities and park staff, identify themes and work out any potential problems.

3. The group leader should discuss park rules and behavioral expectations with adult leaders and participants. Safety should be stressed.

4. *The group leader is responsible for obtaining a parental consent form for each participant*. Be sure that health conditions and medical needs are noted. A sample consent form is located on page 8.2.

5. *If you will be late or need to cancel your trip, please notify the park immediately.*

6. Research activity permits may be required for activities in which samples will be taken from the park. Contact the park to determine if research activity permits are needed.

While at the Park:

Complete the on-site activities in this Environmental Education Learning Experience. As you enjoy the natural setting of the park, remember that the park is for your enjoyment, but please follow all safety adviseries and obey all other park rules and regulations.

1. Be as quiet as possible while in the park. This will help you get the most out of the experience, while increasing the chance of observing wildlife.

2. On hikes, walk behind the leader at all times. Running is not permitted. Please stay on the trails!

3. When hiking and studying at Stone Mountain State Park, please be safety conscious. Some sections of the park's trails are fairly strenuous. It is recommended that proper footwear be worn and that water be carried. Also, hazards such as bees, snakes, ticks, poison ivy and extreme weather conditions do exist. These hazards can cause problems if you are not prepared. Students with any medical conditions should be monitored closely by the adult leaders.

4. All plants and animals are protected within the park. Injuring or removing plants or animals is prohibited in all North Carolina State Parks. Removal of rocks is also prohibited. This allows others the future opportunity to enjoy our natural resources.

5. Picnic only in the designated picnic areas. Help keep the park clean and natural by not littering and by picking up any trash left behind by others.

6. *In case of accidents or emergencies, contact the park staff immediately.*

SAFETY ADVISORY

Teachers should make sure that students stay on designated trails at all times.

The terrain on top of Stone Mountain may appear level, but it becomes gradually steeper downslope. Those who wander off the trails risk a potentially deadly fall.

Following the Trip:

1. Complete the post-visit activities in this Environmental Education Learning Experience.

2. Build upon the field experience and encourage participants to seek answers to questions and problems encountered while at the park.

3. Relate the experience to classroom activities through reports, projects, demonstrations, displays and presentations.

4. Give tests or evaluations, if appropriate, to determine if students have gained the desired information from the experience.

5. Please complete the program evaluation sheet, located on page 8.3, and send it to the park.

Park Information:

Address:

Stone Mountain State Park
3042 Frank Parkway
Roaring Gap, NC 28668
Tel: (336) 957-8185
Fax: (336) 957-3985

Web: www.ncsparks.net

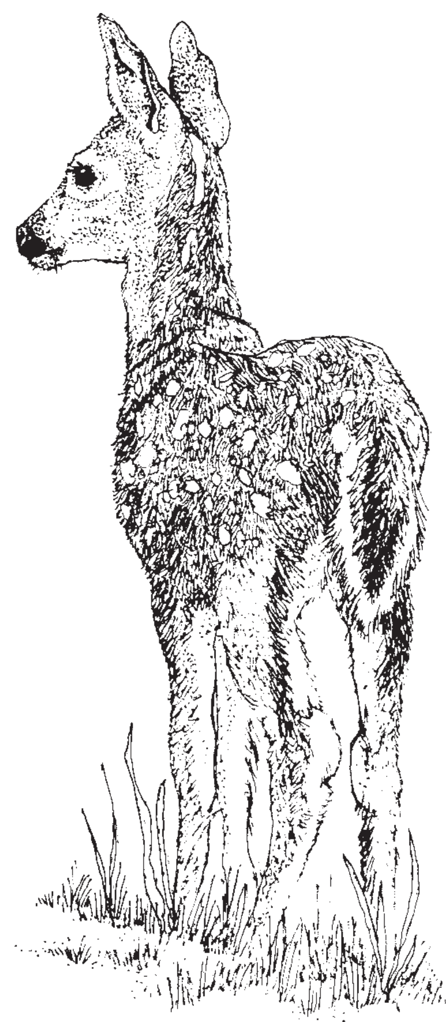
Office Hours:

Year-round

Mon. - Fri.	8 a.m. - 5 p.m.
Sat. & Sun.	open seasonally

Hours of Operation:

Nov.-Feb.	8 a.m. - 6 p.m.
March, Oct.	8 a.m. - 7 p.m.
April, May, Sept.	8 a.m. - 8 p.m.
June-Aug.	8 a.m. - 9 p.m.



Introduction to the Activity Packet for Stone Mountain State Park

Stone Mountain State Park's Environmental Education Learning Experience (EELE), *Our Changing Land,* is designed to introduce the student to the geology of the Blue Ridge Mountains, with emphasis on Stone Mountain, through a series of hands-on activities. This EELE, which is designed for grades 4 - 8, meets curriculum objectives of the standard course of study established by the North Carolina Department of Public Instruction. (See Correlation Chart in Activity Summary.)

Three types of activities are included:

1) pre-visit activities
2) on-site activities
3) post-visit activities

The on-site activities will be conducted at the park, while pre-visit and post-visit activities are designed for the classroom environment. The pre-visit activities should be introduced prior to the park visit so that students will have the necessary background and vocabulary for the on-site activities. We encourage you to use the post-visit activities to reinforce concepts, skills and vocabulary learned in the pre-visit and on-site activities.

The Environmental Education Learning Experience, *Our Changing Land,* will acquaint students with the following major concepts:

- **Rock cycle**
- **Weathering and erosion**
- **Geologic formations in the park (landforms)**
- **Geological time**
- **Sedimentary, metamorphic and igneous rocks**
- **Elements and minerals**
- **Mineral identification**
- **The mining process**
- **Uses of rocks and minerals**
- **Stewardship of natural resources**

The first occurrence of a vocabulary word used in an activity is indicated in **bold type**. A list of definitions can be found at the back of the activity packet. A list of the reference materials used in developing the activities follows the vocabulary list.

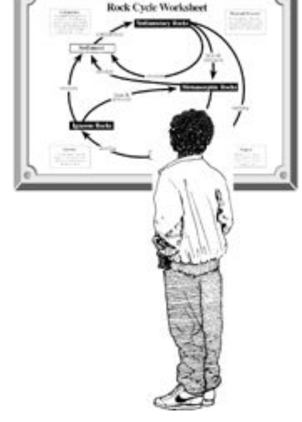
This document was designed to be reproduced, in part or entirety, for use in North Carolina classrooms. If you wish to photocopy or adapt it for other uses, please credit the North Carolina Division of Parks and Recreation.

SAFETY CONCERNS:

Please stay on the trails! The terrain on top of Stone Mountain may appear level, but becomes gradually steeper downslope. Those who wander off the trails risk a potentially deadly fall. Exercise extreme caution when rocks are wet. Steep rocky ledges should be avoided at all times.

The educator will assist in seeing that all safety precautions are followed. It is also the responsibility of the educator to become aware of special considerations, medical needs, etc. of participants and be prepared to take appropriate precautionary measures. Park staff should be informed of any special considerations prior to the group's arrival at the park.

While in the park, please remember that the purpose of the state parks system is to preserve and protect our natural resources. Explain to students that they should not pick, injure, or destroy any plants or animals. Rocks should not be removed from the park, but should be returned to their original positions in the areas from which they were collected.

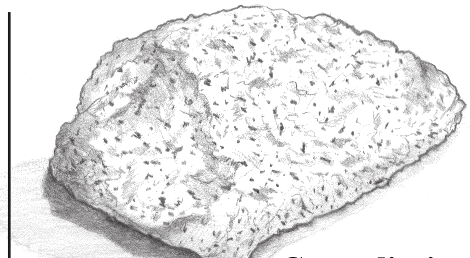


A Brief Geologic History of Stone Mountain State Park

Stone Mountain State Park is underlain by two main rock units. The older, more easily weathered unit is the **Alligator Back Formation**, which actually stretches from northwestern North Carolina into southwestern Virginia. This formation was created over 700 million years ago (late Proterozoic era) from sediments washed into an ancient ocean basin. Ash from ancient volcanoes intermingled with the clay, silt, sand and other **clastic** sediments in this ocean. Lava also flowed out into the basin. Thus, sedimentary rocks interlayered with igneous rocks (basalt) were formed there.

About 500 million years ago, the continents of North America and Africa began to move towards each other. As this occurred, ancient ocean basins began to close and volcanic island chains slammed into the North American continent. During the first of several mountain-building events (**Taconic orogeny**), the interlayered sedimentary and igneous rocks, which were the "parent" rocks (protoliths) to the rocks in today's Alligator Back Formation, were metamorphosed. Metamorphic rocks such as biotite gneiss, mica schist and amphibolite were created. The biotite gneiss found throughout this formation today has a distinctive "pin-striped" appearance. The actual name "Alligator Back Formation" comes from the southwestern face of Bluff Mountain (Alligator Back), which is the type locality for the formation. Here massive ribs of gneiss, extending from the crest of Bluff Mountain, can be seen from the Blue Ridge Parkway. These rock formations resemble the ribs of a giant alligator. Note that Bluff Mountain (Alligator Back) is located northwest of Stone Mountain.

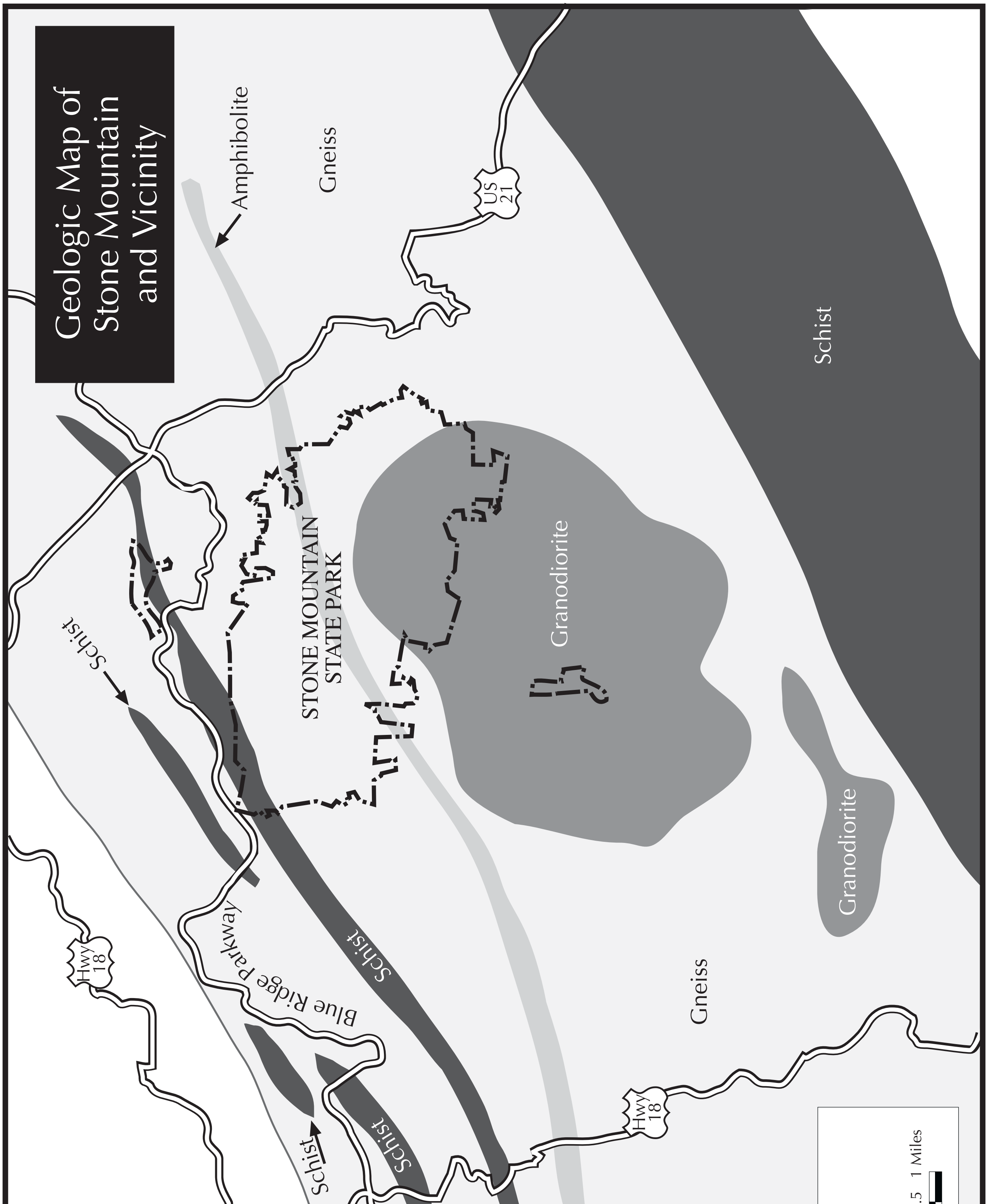
During a second pulse of mountain building in the continental collision between Africa and North America (**Acadian orogeny**), the younger rock unit that makes up the dome of Stone Mountain was created. About 390 million years ago (Devonian period), pockets of magma formed deep in the earth's crust and rose toward the surface. As these large pods of magma migrated upward, they "ate" through and incorporated some of the older rock formations they were moving through. These magma pods crystallized well below the earth's surface, creating bodies of intrusive igneous rock known as **plutons**. The Stone Mountain pluton is com-

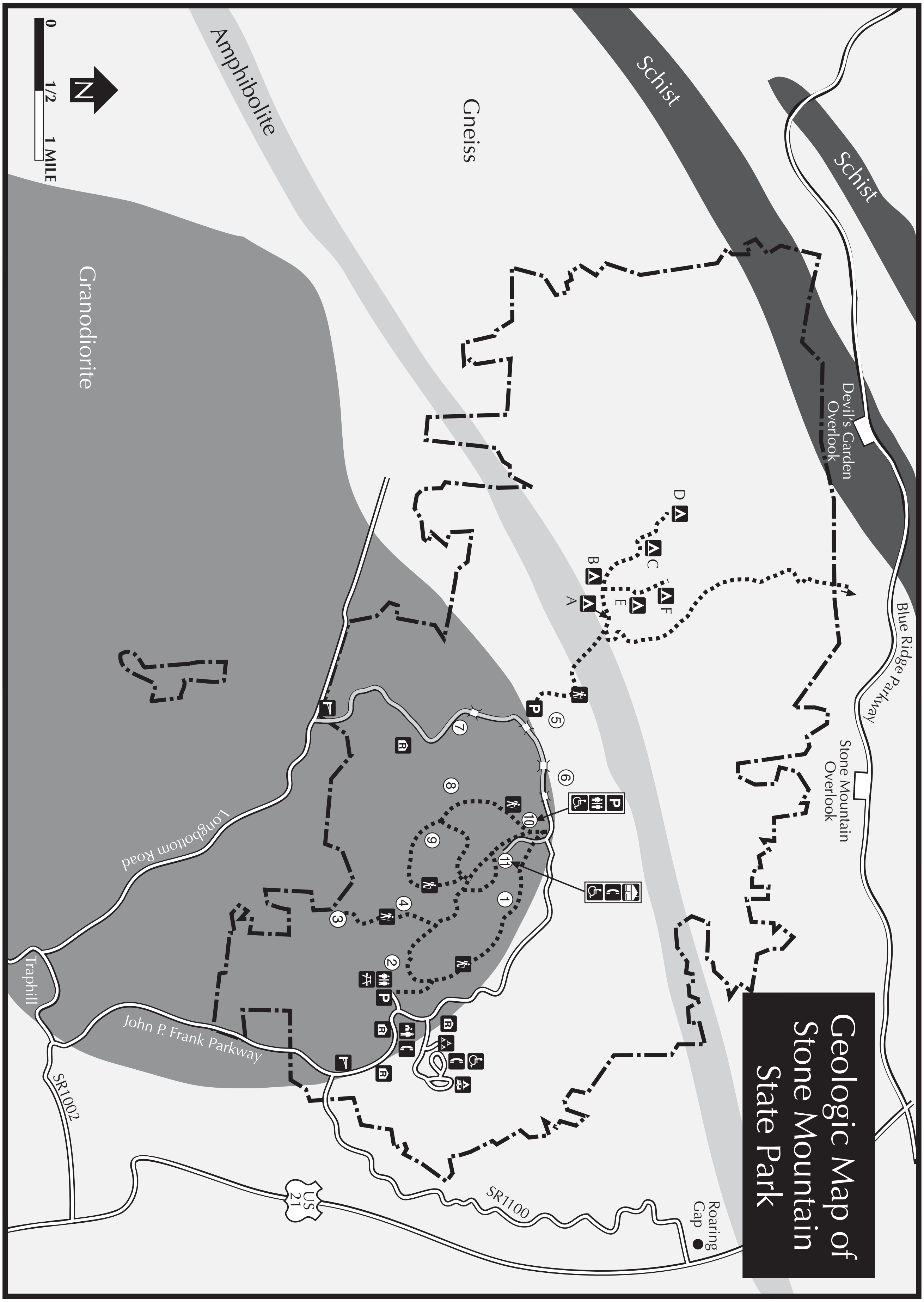


Granodiorite

posed of **granodiorite**, a rock that is similar to granite but contains *less* potassium feldspar (orthoclase) and *more* sodium feldspar (plagioclase). Granodiorite may also contain more biotite, hornblende or other dark-colored minerals than granite does.

The Stone Mountain pluton solidified around the same time as the plutons in Spruce Pine and Mt. Airy. It took millions of years of erosion to remove the overlying rock and expose these plutons at the earth's surface. When the overlying rock weathers and is eroded away, pressure on the underlying rock is released and the rock expands upward and outward. As the granodiorite expands, joints or cracks form parallel to the surface. The thin, curved sheets of weathered rock eventually fall off and, through continued weathering and erosion, the mountain gradually takes on a curved, domelike appearance. This weathering process is called **exfoliation** and the resulting landform is known as an **exfoliation dome**.


Geologic Map of Stone Mountain and Vicinity
Amphibolite
Gneiss
US 21
Schist
STONE MOUNTAIN STATE PARK
Granodiorite
Granodiorite
Schist
Schist
Blue Ridge Parkway
Hwy 18
Hwy 18
Gneiss
Schist
Schist
Hwy 113
Hwy 88
N
0.5 0 0.5 1 Miles


Geologic Map of Stone Mountain State Park
Granodiorite
Gneiss
Amphibolite
Schist
Schist
Devil's Garden Overlook
Stone Mountain Overlook
Blue Ridge Parkway
Longbottom Road
John P. Frank Parkway
Traphill
SR1002
SR1100
US 21
Roaring Gap
N
0
1/2
1 MILE

Legend for Geologic Maps

LEGEND

Accessible	Park Office
Backcountry Camping	Parking
Park Boundary	Picnicking
Bridge	Public Telephone
Family Camping	Ranger Residence
Group Camping	Restrooms
Hiking Trail	Road - Gravel
Historic Site	Road - Paved
Park Gate	

NUMBERED ITEMS

1. Stone Mountain
2. Stone Mountain Falls
3. Lower Falls
4. Middle Falls
5. Widow's Creek Falls
6. Fish for Fun Registration
7. Garden Creek Baptist Church
8. Wolf Rock
9. Cedar Rock
10. Parking Area to Access Trailhead and Hutchinson Homestead
11. Historic Hutchinson Homestead and View of Stone Mountain

KEY TO ROCK UNITS

Amphibolite
(Alligator Back Formation)

Gneiss
(Alligator Back Formation)

Mica Schist & Phyllite
(Alligator Back Formation)

Quartz Diorite to Granodiorite
(Pluton)

Activity Summary

The following outline provides a brief summary of each activity, the major concepts introduced and the objectives met by completion of the activity.

I. Pre-Visit Activities

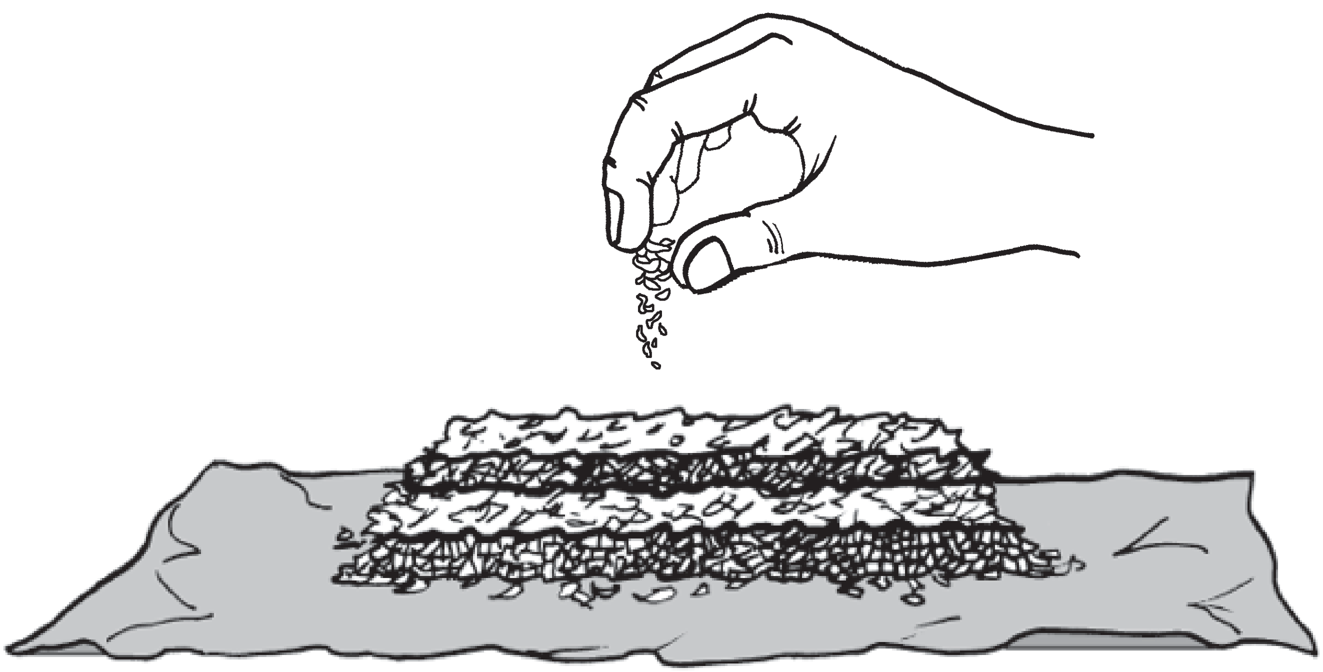
#1 The Pressure's On (page 3.1.1)

Through this activity, students will learn how sedimentary, metamorphic and igneous rocks are formed, and how they are interrelated via the rock cycle.

Major Concepts:
- Rock cycle
- Mechanical weathering
- Sedimentary rock formation
- Metamorphic rock formation
- Igneous rock formation

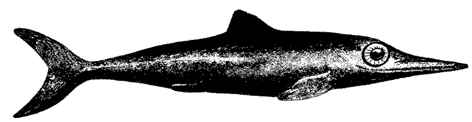
Learning Skills:
- Observing, classifying, inferring and making models
- Following directions to create a product
- Measuring length and volume

Objectives:
- List the three main rock classifications.
- Describe how the three rock classifications are formed.
- Explain the rock cycle.
- Name the two rock types found in and around Stone Mountain State Park today.



#2 Let's Do the Time Warp (page 3.2.1)

The vast scale of geologic time is difficult to envision for most people. This activity presents geologic time in a pictorial representation that makes it easier to comprehend.



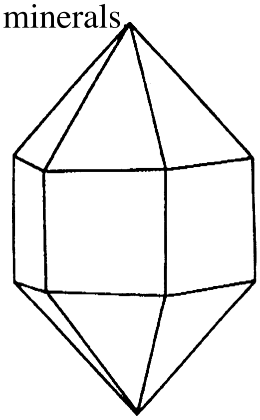
Major Concepts:
- Geologic time
- Geologic history

Learning Skills:
- Observing, inferring, using models
- Organizing and expanding information; creating a product
- Measuring

Objectives:
- List the four units of geologic time.
- Conceptualize geologic time using a mural model.
- Name the epoch, period and era in which we live.
- Name the period and era in which the Stone Mountain pluton was formed.

#3 Mineral Study (page 3.3.1)

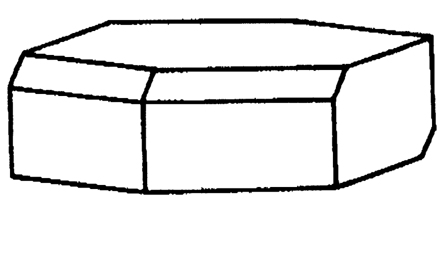
In this activity, students will examine three minerals commonly found in granodiorite rock: feldspar, quartz and biotite. Students will learn about the uses of each mineral and where they are mined in the state. They will study the chemical formula for each mineral and use a periodic table to discover the elements contained in each. Optional activities include making mobiles or 3-D models of the crystals of these three minerals.



Major concepts:
- Composition of minerals
- Crystal shape
- Properties and uses of minerals

Learning Skills:
- Observing, classifying, inferring
- Noting important details and drawing conclusions
- Reading charts, tables and maps

Objectives:
- Name three minerals found in granodiorite rock at Stone Mountain.
- Describe the chemical composition and crystal shape of feldspar, quartz and biotite.
- List at least two uses for feldspar, quartz and biotite.



II. On-Site Activities

#1 Igneous Intruder (page 4.1.1)

In Part I, “Igneous Intruder,” students will participate in a simulation at the park that illustrates a geological theory for how Stone Mountain was formed. In Part II, “Rock Walk,” the students will see first-hand examples of weathering, erosion, deposition and succession on the self-guided nature trail at the base of Stone Mountain.

Part I: Igneous Intruder

Major Concepts:
- Intrusive igneous rock
- Erosion
- Landforms – pluton and exfoliation dome

Learning Skills
- Observing, classifying, communicating, inferring, making models
- Writing descriptive and expository text

Objectives:
- Describe and illustrate how Stone Mountain was formed.
- List three minerals found in the granodiorite of Stone Mountain.
- Demonstrate awareness of the importance of plutons and exfoliation domes to human society.

Part II: Rock Walk

Major Concepts:
- Weathering and erosion
- Deposition
- Land use
- Succession of plants and soils

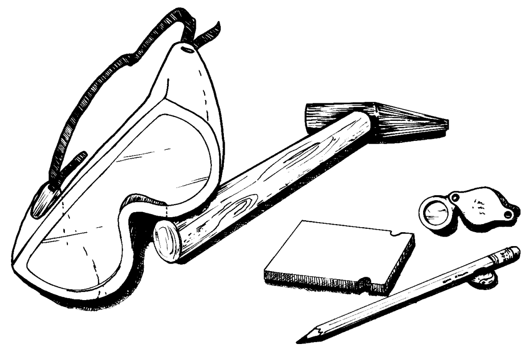
Learning Skills
- Observing, classifying, communicating, inferring
- Collecting, analyzing and evaluating information

Objectives:
- Describe five factors that cause rocks to weather.
- List five agents of erosion.
- Describe bare rock succession and soil formation.
- List three ways early settlers used the rocks in this area and two ways we use them today.

#2 Mineral Detectives (page 4.2.1)

Minerals are identified using various physical characteristics, such as hardness, color, streak, luster, and cleavage. In this activity, your students will learn about some of these characteristics and their common field tests. The students will be given unknown mineral samples and mineral identification tools and asked to identify the samples using a key.

Major Concepts:
- Minerals
- Mineral identification
- Properties of minerals



Learning Skills:
- Observing, classifying, inferring
- Reading a scientific key

Objectives:
- Name at least four physical characteristics that help geologists classify minerals.
- Demonstrate the ability to correctly and safely perform tests for hardness, cleavage, and streak on several different mineral samples.
- Use observation skills and an identification key to classify at least five unknown minerals.

#3 Exploration to the Falls (page 4.3.1)

This activity is a hike with nine stops on the Stone Mountain Connector and Stone Mountain Loop trails. Students will make qualitative and quantitative observations of weathering pits, sheet joints, dikes, stream erosion, cascades and exfoliation. They will develop an explanation for how Stone Mountain achieved its domelike shape.

Major Concepts:
- Intrusive igneous rocks
- Geologic formations
- Mountain-building processes
- Weathering and erosion

Learning Skills:
- Observing, classifying, communicating, inferring
- Collecting, analyzing and evaluating information

Objectives:
- Describe how intrusive igneous rocks are formed and name the igneous rock at Stone Mountain.
- Name at least three minerals found in granodiorite.
- Gain an appreciation for the geologic formations in Stone Mountain State Park.
- Describe at least three weathering features in the granodiorite including weathering pits, exfoliation sheets and differential weathering.
- Explain how the dome-shaped appearance of Stone Mountain developed over time.

III. Post-Visit Activities

#1 Minerals In Our Lives (page 3.4.1)

In this activity, the students will read a story about a day in the life of a typical family. Students will highlight the names of products or materials that come from rocks and minerals. They will then write about their own typical day and identify how many times they come in contact with items manufactured using minerals.

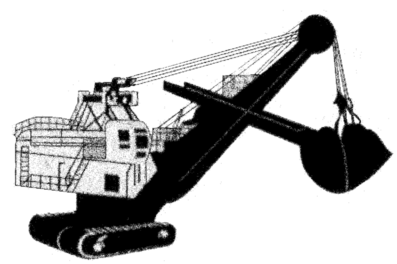
Major Concepts:
- Uses of rocks and minerals
- Nonrenewable resources
- Availability of resources

Learning Skills:
- Communicating, observing and classifying
- Analyzing information
- Writing a journal entry and constructing a glossary

Objectives:
- Identify everyday items that come from rocks and minerals.
- Complete a journal entry of a typical day noting the many products used that come from rocks and minerals.
- Describe how life would be changed without products derived from rocks and minerals.
- Explain the impact of a growing world population on the earth's mineral resources.
- Describe at least three ways each of us can conserve mineral resources.

#2 Do You Mine? (page 5.2.1)

Students will explore different viewpoints surrounding a proposed mining operation near a fictitious state park. Each student will write an essay representing a particular interest group, then work toward a group solution to this issue.



Major Concepts:
- Mining
- Environmental issues
- Conservation of natural resources

Learning Skills:
- Predicting, communicating
- Participating effectively in groups, problem solving
- Using language for personal response
- Evaluating the accuracy and value of information and ideas

Objectives:
- Write an essay supporting or opposing a proposed mining operation near a state park. Provide at least three logical reasons to support the position.
- Listen critically to oral presentations and write notes of key points.
- Demonstrate a willingness to acknowledge other points of view and work toward a group solution to a natural resource issue.

#3 Mining in a Nutshell (page 5.3.1)

In this activity, students will particpate in a simulation to learn the steps that mining companies must take to find, extract and process mineral resources. The manufacture and consumption of products made from minerals is also experienced and discussed. Students will read about the reclamation process and consider how miners can reduce their environmental impacts.

Major Concepts:

- The phases of mining operations
- Raw material consumption
- Reclamation

Learning Skills:

- Observing, classifying, inferring
- Noting important details and drawing conclusions
- Gathering and organizing information
- Mapping

Objectives:

- List and describe at least five phases in mining earth resources from the initial discovery of a mineral deposit through society's consumption of a finished mineral product.
- Explain at least three ways that mining companies can reduce environmental impacts.

CORRELATION CHART - Stone Mountain

Stone Mountain State Park's EELE: *Our Changing Land*

Note to classroom teachers: The following Correlation Charts show how each activity in this Environmental Education Learning Experience (EELE) correlates with the North Carolina Department of Public Instruction (DPI) objectives in science, mathematics, social studies and English language arts. The activities are listed in the order in which they appear in this EELE. The recommended grade levels are listed along the side of the chart. Notice that only the objective numbers are listed. Use your DPI Teacher Handbook for each subject area to get a complete description of the objectives in that subject area.

Pre-Visit Activity #1: The Pressure's On, p. 3.1.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.04 Nature of Science Science as Inquiry	Competency Goals 1&2, 4.02, 4.07, 4.09		2.7
5	3.01 Nature of Science Science as Inquiry	Competency Goals 1&2, 4.02, 4.07, 4.09		
6	4.02 Nature of Science Science as Inquiry	1.03, 2.01, 5.01, 6.01		2.10, 2.11
7		1.03, 1.04, 2.01, 2.02, 5.01, 6.01		2.9
8	3.01, 3.04 Nature of Science Science as Inquiry	1.03, 1.04, 2.01, 4.02, 5.01, 6.01		2.7
Earth/ Envtl Science	1.02, 3.03 Nature of Science Science as Inquiry			

Pre-Visit Activity #2: Let's Do the Time Warp, p. 3.2.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	1.03 Nature of Science	Competency Goals 1& 2, 3.03, 3.06, 4.02, 4.03		2.4, 2.7, 4.3, 4.4
5	1.06, 3.01 Nature of Science	Competency Goals 1& 2, 3.01, 3.06, 4.02, 4.03		1.1
6		1.02, 1.03, 2.01, 2.02, 4.02, 5.01, 5.02, 6.01		1.1, 2.11
7		1.01, 1.02, 2.01, 2.02, 4.02, 5.01, 5.02, 6.01		1.1
8	3.01, 3.02, 3.03 Nature of Science	1.03, 1.04, 2.01, 2.02, 4.02, 5.01, 5.02, 6.01		1.5, 2.12
Earth/ Envtl Science	3.01, 3.02, 3.03 Nature of Science			

Pre-Visit Activity #3: Mineral Study, p. 3.3.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.01, 2.02, 2.03 Nature of Science	Competency Goals 1 & 2	1.01, 6.04 <u>Skills:</u> 1.01, 1.02, 1.08, 2.01, 3.01	
5		Competency Goals 1 & 2 also 4.02	1.01 <u>Skills:</u> 1.01, 1.02, 1.08, 2.01, 3.01	
6		1.03, 1.04, 2.01, 5.01		
7	4.01, 4.02 Nature of Science	1.03, 1.04, 2.01, 5.01		
8		1.03, 1.04, 2.01, 5.01		
Earth/ Envtl Science	1.01, 1.03, 1.06 Nature of Science			

On-Site Activity #1: Igneous Intruder, Part I, p. 4.1.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.02, 2.03 Nature of Science Science as Inquiry	Competency Goals 1& 2 also 4.02, 4.06, 4.09, 5.01, 5.02, 5.03	1.01, 1.04, 6.04 Skills: 1.01, 1.02, 1.03, 1.04, 2.04, 2.05, 2.06, 4.01, 4.06, 4.08	
5	3.01, 3.03 Nature of Science Science as Inquiry	Competency Goals 1& 2 also 4.02, 4.06, 4.09, 5.01, 5.02, 5.03	1.01, 1.06 Skills: 1.01, 1.02, 1.03, 1.04, 2.04, 2.05, 2.06, 4.01, 4.06, 4.08	
6		1.03, 1.04, 2.01, 3.01, 3.03, 4.02, 5.01, 6.01		
7		1.03, 1.04, 2.01, 3.01, 3.03, 4.02, 5.01, 6.01		
8	3.01, 3.04 Nature of Science Science as Inquiry	1.03, 1.04, 2.01, 3.01, 3.03, 4.02, 5.01, 6.01		
Earth/ Envtl Science	1.02, 1.03, 1.05 Nature of Science Science as Inquiry			

On-Site Activity #1: Igneous Intruder, Part II, p. 4.1.8

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	1.03, 2.03 Nature of Science Science as Inquiry	Competency Goals 1 & 2 also 4.02, 4.09	1.01, 1.04, 6.04 Skills: 1.01, 1.02, 1.03, 1.04, 2.04, 4.01, 4.06, 4.08	
5	1.01, 1.04, 1.06, 3.01, 3.03 Nature of Science Science as Inquiry	Competency Goals 1 & 2 also 4.02, 4.09	1.01, 1.06 Skills: 1.01, 1.02, 1.03, 1.04, 2.04, 4.01, 4.06, 4.08	
6	1.01, 1.03, 2.03 Nature of Science Science as Inquiry	1.03, 1.04, 2.01, 4.02, 5.01		
7		1.03, 1.04, 2.01, 4.02, 5.01		
8	3.01, 3.04, 4.01 Nature of Science Science as Inquiry	1.03, 1.04, 2.01, 4.02, 5.01	5.01, 5.02 Skills: 1.01, 1.02, 1.08, 2.04, 4.01, 4.06, 4.08	
Earth/ Envtl Science	1.02, 1.04, 1.05, 4.01 Nature of Science Science as Inquiry			

On-Site Activity #2: Mineral Detectives, p. 4.2.1

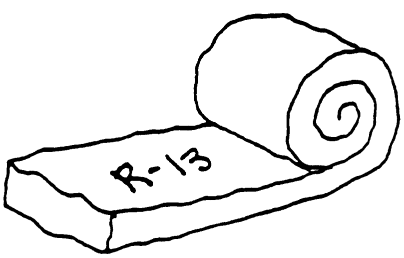
Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.01, 2.02, 4.01 Nature of Science Science as Inquiry Science & Tech.	1.04, 2.01, 2.02, 2.09, 4.02		
5		1.04, 2.01, 2.02, 2.09, 4.02		
6		1.03, 1.04, 2.01, 4.02		
7	4.01, 4.02 Nature of Science Science as Inquiry Science & Tech.	1.03, 1.04, 2.01, 4.02		
8		1.03, 1.04, 2.01, 4.02		
Earth/ Envtl Science	1.01 Nature of Science Science as Inquiry			

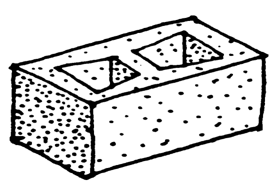
On-Site Activity #3: Exploration to the Falls, p. 4.3.1

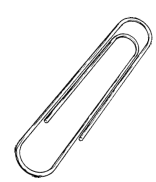
Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	1.03, 2.02, 2.04 Nature of Science Science as Inquiry	Competency Goals 1 & 2 also 3.01, 4.02, 4.09	1.01, 1.04 <u>Skills:</u> 1.01, 1.02, 1.03, 1.04, 2.04, 3.01, 3.05	2.1, 2.3, 2.4, 2.7
5	1.01, 1.06, 3.01, 3.02, 3.03 Nature of Science Science as Inquiry	Competency Goals 1 & 2 also 3.01, 4.02, 4.09	1.01, 1.06 <u>Skills:</u> 1.01, 1.02, 1.03, 1.04, 2.04, 3.01, 3.05	2.9
6	1.01, 1.03, 2.03 Nature of Science Science as Inquiry	1.02, 1.03, 1.04, 2.01, 4.02, 5.01, 6.01		2.11, 2.12, 2.13
7		1.02, 1.03, 1.04, 2.01, 4.02, 5.01, 6.01		2.2, 2.12
8	2.03, 3.01, 3.02, 3.04 Nature of Science Science as Inquiry Science & Tech.	1.02, 1.03, 1.04, 2.01, 4.02, 5.01, 6.01		
Earth/ Envtl Science	1.02, 1.03, 1.04, 1.05, 1.06 Nature of Science Science as Inquiry Science & Tech.			

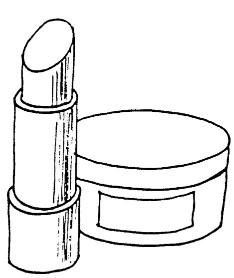
Post-Visit Activity #1: Minerals in Our Lives, p. 5.1.1

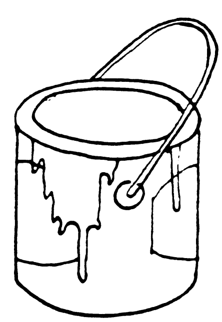
Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.03, 4.01, 4.05 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 2 also 3.01, 3.03, 3.06, 4.01, 4.02, 4.05, 4.07, 4.09, 5.01	1.04, 6.01, 6.04, 6.08, 7.04, 7.05 Skills: 1.01, 1.02, 1.03, 1.08, 2.01, 4.01, 4.05, 4.06, 4.07	
5	2.02 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 2 also 3.01, 3.03, 3.06, 4.01, 4.02, 4.05, 4.07, 4.09, 5.01	1.06, 5.01, 5.02, 6.01, 6.02, 6.05 Skills: 1.01, 1.02, 1.03, 1.08, 2.01, 4.01, 4.05, 4.06, 4.07	
6	1.03, 2.03 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 5 also 2.01, 4.02, 6.01		
7	4.01, 4.03 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 5 also 2.01, 4.02, 6.01		
8	2.01, 2.02, 2.05 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 5 also 2.01, 4.02, 6.01	7.03, 8.02, 9.01 Skills: 1.01, 1.02, 1.03, 1.08, 2.01, 4.01, 4.05, 4.06, 4.07	
Earth/ Envtl Science	1.03, 7.01, 7.02, 7.03 Science & Tech. Per. & Social Persp.			









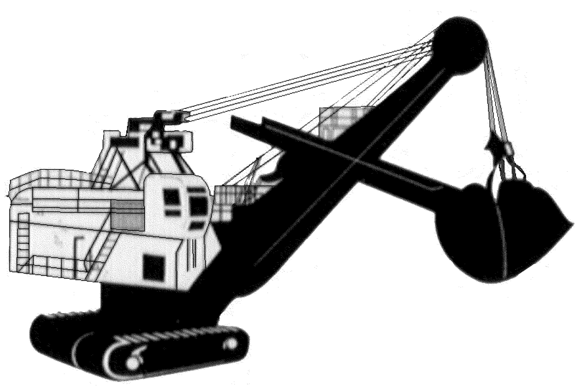


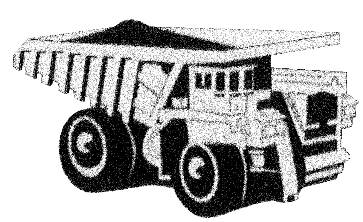
Post-Visit Activity #2: Do You Mine?, p. 5.2.1

Grade	Science	English Lang. Arts	Social Studies	Mathematics
4	2.03 Science & Tech. Per. & Social Persp.	Competency Goals 1, 2 & 5; also 3.01, 3.05, 3.06, 4.02, 4.03, 4.07	1.03,1.04, 4.03, 4.04, 6.01, 6.02, 6.04, 7.02, 7.05 Skills: 1.03, 1.04, 1.05,1.07, 2.01, 2.06, 3.01, 3.03, 4.01, 4.02, 4.03, 4.04, 4.05, 5.04	
5	1.03, 1.06, 2.02, 3.01 Science & Tech. Per. & Social Persp.	Competency Goals 1, 2 & 5; also 3.01,3.05, 3.06, 4.02, 4.03, 4.07	1.06, 2.04, 5.01, 6.02, 6.04 Skills: 1.03, 1.04, 1.05,1.07, 2.01, 2.06, 3.01, 3.03, 4.01, 4.02, 4.03, 4.04, 4.05, 5.04	
6	1.01, 1.03 Science & Tech. Per. & Social Persp.	Competency Goals 1, 2, 3, 4 & 6; also 5.01		
7	1.04 Science & Tech. Per. & Social Persp.	Competency Goals 1, 2, 3, 4 & 6; also 5.01		
8	1.04, 1.05, 2.01, 2.03, 2.03, 2.04, 2.05, 3.04 Science & Tech. Per. & Social Persp.	Competency Goals 2, 3, 4, & 6; also 1.02, 1.03, 1.04, 5.01	8.02, 8.04, 9.01, 9.03 Skills: 1.03, 1.04, 1.05, 1.07, 2.01, 2.06, 3.01, 3.03, 4.01, 4.02, 4.03, 4.04, 4.05, 5.04	
Earth/ Envtl Science	1.03, 1.05, 1.06, 4.01, 7.01, 7.02, 7.03 Science & Tech. Per. & Social Persp.			

Post-Visit Activity #3: Mining In a Nutshell, p. 5.3.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
4	2.03, 4.03, 4.05 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 2, also 4.02, 4.05	1.04, 4.03, 6.01, 6.04, 7.02, 7.05 Skills: 1.01, 1.02, 1.03, 2.01, 3.01, 4.01, 4.03	
5	1.04, 2.02, 3.01 Science & Tech. Per. & Social Persp.	Competency Goals 1 & 2, also 4.02, 4.05	1.06, 5.01, 6.02, 6.03, 6.06 Skills: 1.01, 1.02, 1.03, 2.01, 3.01, 4.01, 4.03	
6	1.01, 1.03, 2.03 Science & Tech. Per. & Social Persp.	1.02, 1.03, 1.04, 2.01, 4.02, 5.01		
7	1.04 Science & Tech. Per. & Social Persp.	1.02, 1.03, 1.04, 2.01, 4.02, 5.01		
8	1.04, 1.05, 2.01, 2.02, 2.03, 2.05 Science & Tech. Per. & Social Persp.	1.02, 1.03, 1.04, 2.01, 4.02, 5.01	8.02, 9.01 Skills: 1.01, 1.02, 1.03, 2.01, 3.01, 4.01, 4.03	
Earth/ Envtl Science	1.03, 1.04, 7.01, 7.02, 7.03 Science & Tech. Per. & Social Persp.			





Pre-Visit Activity #1 — The Pressure's On

Major Concepts:
- Rock cycle
- Mechanical weathering
- Sedimentary rock formation
- Metamorphic rock formation
- Igneous rock formation

Learning Skills:
- Observing, classifying, inferring and making models
- Following directions to create a product
- Measuring length and volume

Subject Areas:
- Science
- English Language Arts
- Mathematics

* See Activity Summary for a Correlation with DPI objectives in these subject areas.

Location:
Classroom/Science lab

Group Size:
30 students or less, class size

Estimated Time: 2 to 4 hours

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: One copy of Student's Information and Rock Cycle Diagram, safety goggles, large pocket pencil sharpener, four wax crayons of the same color, (either red, green, blue, or yellow crayons), envelopes, wax paper
Per group: Metric ruler, hot plate, two oven mittens, aluminum foil, three disposable aluminum foil pie pans, trivet, newspaper (enough to cover lab surfaces, plus extra), one 8-inch C-clamp, two pieces of plywood – approximately 25 by 25 centimeters
Per class: Samples of actual sedimentary, metamorphic and igneous rocks (contact the park if you need to borrow a rock set), crushed ice, water

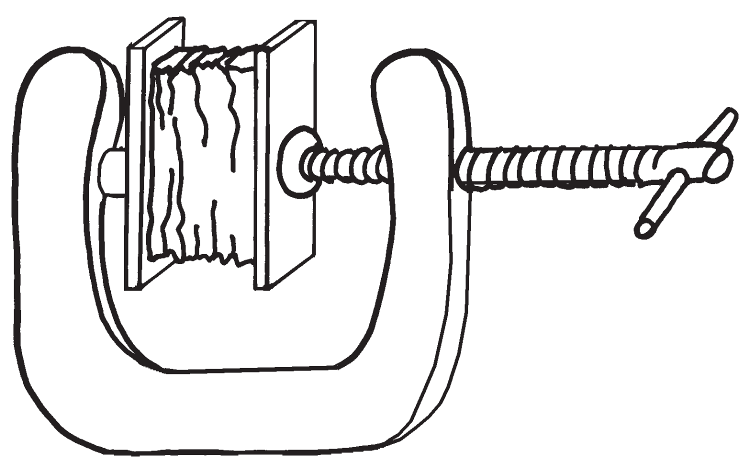
Special Considerations:
Take proper safety precautions. Hot plate and hot crayon wax can cause burns. C-clamps can pinch/crush fingers.

Objectives:
- List the three main rock classifications.
- Describe how the three rock classifications are formed.
- Explain the rock cycle.
- Name the two rock types found in and around Stone Mountain State Park today.

Educator's Information:

Students often have difficulty understanding the abstract concept of the **rock cycle**. The students can view rock samples in the classroom; the difficulty lies in their inability to visualize how these **rocks** were formed. The following activity is extremely effective in giving students the opportunity to experience the rock cycle. Students will simulate **mechanical weathering**, **erosional** processes, and the formation of **sedimentary**, **metamorphic** and **igneous rocks**. The activity can be done as one continuous process or divided into five separate lessons.

Some educators may want to incorporate more mathematics into the activities. Suggestions for quantitative observations are given in brackets.



Instructions:

Set the stage by asking students to describe local rocks or rock formations, or ones that they have seen during walks along a river's edge, on a mountain, or during drives along highways that were built through road cuts. Be sure to have several rock samples distributed around the room.

Ask the students questions such as, "Have you ever wondered just how these rocks form?" and "Are new rocks forming at this moment?" Ask each student to write down one rock-related question they would like to have answered in class. Have students read the Student's Information and accompanying Rock Cycle Diagram. Discuss the three classifications of rocks: sedimentary, metamorphic and igneous. You may also want to introduce the geologic history of Stone Mountain given on page 1.7.

Part A: Weathering

Each student should complete "The Pressure's On" worksheet as they do this activity. Cover all desk tops with newspaper. Give each student a sheet of wax paper, a pocket pencil sharpener and four crayons of the same color. The crayons represent rock material and the pencil sharpeners represent **weathering** agents. Students should remove the paper from the outside of their crayons and carefully shave the crayons with the pencil sharpener. All of the crayon fragments (which represent rock **sediments**) should be kept in a small pile on the wax paper. Do not mix the colors – each student should use his/her own piece of wax paper.

As the students are "weathering" their crayons, call their attention to the size and shape of the fragments. Remind them that many of the rocks in the Blue Ridge Mountains today probably have their origins in sediments that accumulated in an ancient ocean over 700 million years ago. Discuss the following questions:

• Do you think that weathered fragments of rocks are all the same size or shape?

(Answer: No.)

• Why or why not?

(Answer: The process of weathering depends on the chemical composition of the rock as well as environmental factors such as temperature, humidity, the presence of plants and animals, etc.)

• What are some of nature's weathering forces?

(Answer: **Mechanical weathering** forces can include water, ice, wind, growing roots, worms and burrowing animals, lightning and human activities. In addition, heating and cooling can cause rocks to expand and contract, and then break.

Chemical weathering forces include oxygen, carbon dioxide and water, which react with a rock or mineral resulting in a chemical change. At Stone Mountain, a chemical weathering process called **exfoliation** causes curved sheets of rock to be sloughed off like the layers of skin on an onion.

When the "weathering" is complete, the students should wrap their fragments in wax paper and place each wax paper packet in an envelope, unless you plan to do Part B immediately. Label each envelope as to its contents, "red," "yellow," etc., for proper distribution when the activity is resumed.

Part B: Erosion

Once rock fragments have been created, they are usually moved by some force of nature. Here, the students act as the erosive force as they move the envelopes containing the fragments within the room.

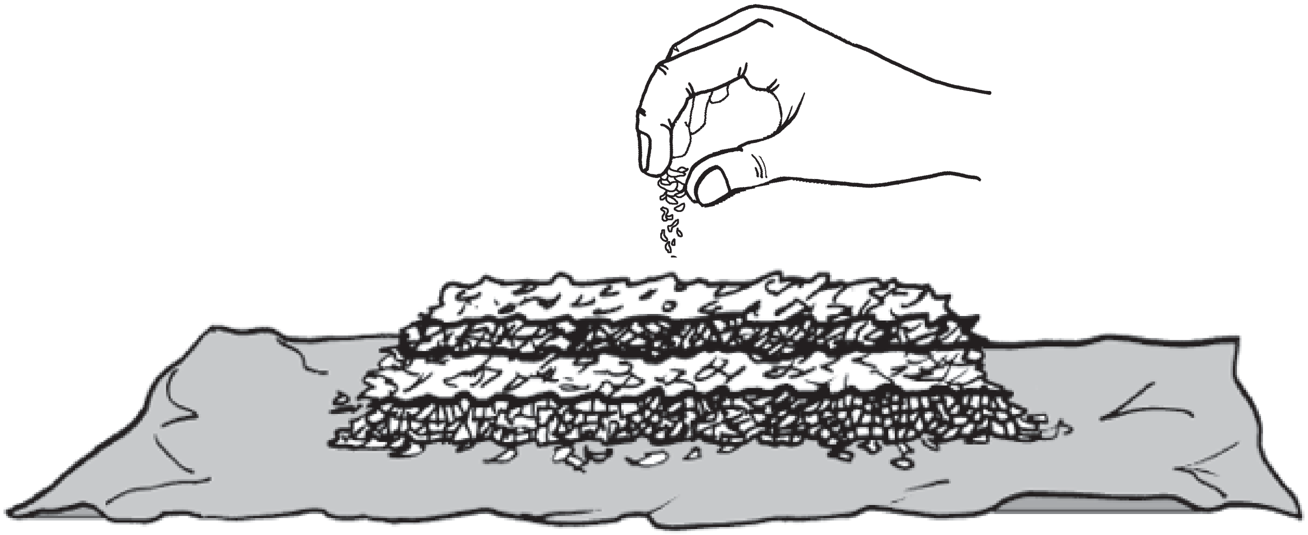
• What is this force of movement called and what are some of its causes? (Answer: Erosion, caused by water – such as streams, rivers and ocean waves – and by wind.)

• Where do rock fragments tend to collect? (Answer: Downhill from where they were first formed.)

• Why? (Answer: Gravity.)

• Why do similarly-sized fragments seem to be found together?

(Answer: Because similar weathering processes will usually take place in one particular area. Smaller, lighter rock fragments will be carried farther away in a winnowing effect.)



Place all the weathered "rock" fragments in four separate piles, one color to a pile. Divide the class into groups of four. Ask each group to measure and cut a sheet of aluminum foil, 31 cm x 45 cm. A student from each group should chose one color and carefully transfer some of the "weathered" fragments to the center of their aluminum foil. Make a rectangular layer, approximately 11cm x 13cm, with a thickness of 1cm. Repeat with the remaining colors, layering them one on top of another (see illustration). Students in each group should take turns creating a layer. [Students might calculate the volume of the fragment pile (length x width x height).]

Students should record observations of their "weathered" fragments on "The Pressure's On" worksheet. Fold the foil over the fragment layers, allowing for a 1-cm space all around the fragments, and then carefully fold the edges to seal the packages. If you are breaking the activity into sections, stop here and label each package for proper distribution when the activity is resumed.

Part C: Sedimentary Rock Simulation

Instruct the groups to place their folded foil package between two pieces of plywood. Apply very *light* pressure with the C-clamp to compress the plywood pieces and the "rock" fragments that are between them. Once the "rock sandwich" has been lightly compressed, remove it from the C-clamp. Students should then carefully open their packages and observe the new product. [Students can measure the length, width and height of their "sedimentary rock" and calculate the change in volume.] Call their attention to the central region that is more tightly compressed. They should lift this portion from the non-compressed fragments and carefully break it into two parts. Look at the broken edges and describe the layers.

- How do they compare with the original layers? What happened to the spaces between the fragments?

(Answer: The layers are thinner and the spaces between the crayon fragments are now smaller.)

Each group should transfer a few of their loose fragments and the smaller piece of the "sedimentary rock" into one of their pie pans. Place the rest of the fragments in an envelope (for Part E). The pieces in the pie pan will be used for comparison with the other "rocks" the students will produce during this activity. Return the larger piece of "sedimentary rock" to the aluminum foil and wrap it up again. [Students should calculate and record the volume of this larger "sedimentary rock."]

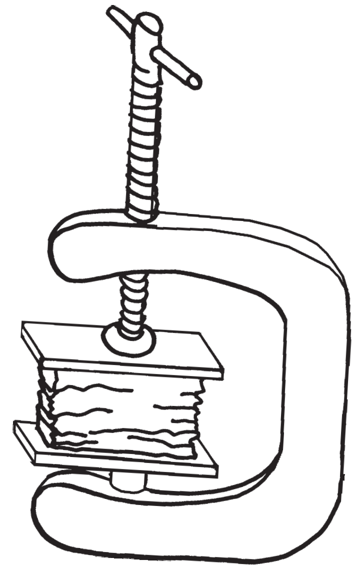
Compare real sedimentary rocks with the sedimentary "crayon rocks." Discuss: one type of rock found in the area around Stone Mountain is called biotite gneiss. It was formed around 700 million years ago from sediments laid down in a shallow basin or sea.

Later, these sediments were buried and compacted, forming sedimentary rock. About 450 million years ago, the North American continent began to collide with Africa. The resulting heat and pressure changed the buried sedimentary rock into metamorphic rock (biotite gneiss). Over millions of years, the gneiss was eroded away and the landscape we see at Stone Mountain today was gradually exposed.

There is no true sedimentary rock left in the area around Stone Mountain. This is because metamorphism has changed the original sedimentary rock into metamorphic rock as the rock layers were buried, heated, folded and pressed together. As the next activity demonstrates, the original crayon fragments are hardly recognizable after "metamorphism."

If available, have the class examine a sedimentary rock with **fossils** in it. Almost all fossils are found in sedimentary rock. Due to the heat, folding and pressure required to create metamorphic and igneous rocks, any fossils that might have been present are usually destroyed. Since most of the rock at Stone Mountain State Park is igneous, no fossils have been found here.

If you are breaking the activity into sections, stop here and label each group's materials for proper distribution later.



Part D: Metamorphic Rock Simulation

Each group should place their foil package with the larger "sedimentary rock" from Part C between the two plywood boards and the C-clamp again. Tell the students to tighten the C-clamp as much as they can this time. This part of the activity demonstrates the need for greater pressure to cause a rock to metamorphose. In reality, as the pressure deep within the earth increases, the temperature increases as well. A temperature change is probably occurring in this activity, but we do not have the equipment to measure this change. Also, the chemical changes associated with the formation of real metamorphic rock cannot be simulated in this activity. It is important students understand that metamorphic rock may become contorted in appearance and actually flow like taffy or toothpaste in response to the pressure caused by the overriding rock load and continental plate movement.

Have the students release the compression on the C-clamp, remove the foil package and open it carefully to examine the newly formed "metamorphic rock." [Again, students should calculate the volume of the new "rock" and compare to the former volume calculated at the end of Part C.] They should carefully break this "rock" into two parts and examine it, noting what happened to the thickness, fragment shape and surface. The students should write their observations on their worksheet. (The different colored "rock fragments" will be squeezed together.)

Examine a real metamorphic rock and compare it to the metamorphic "crayon rock." Also compare the real metamorphic rock to the real sedimentary rock. Have the students examine the texture, the edges and overall appearance of these rocks. Remember, as the continents collided between 450 and 250 million years ago, the sedimentary rock was turned into metamorphic rock by heat and pressure.

Place the smaller piece of "metamorphic rock" into the pie pan with the fragments and the first sedimentary "rock" sample the students made. The larger piece of "metamorphic rock" will go in an envelope labeled "metamorphic."

(You can reuse envelopes used earlier to hold the crayon fragments.) If you are breaking the activity into sections, stop here and label each group's materials for proper distribution later.

Part E: Igneous Rock Formation

> **Safety Note:** This portion of the activity requires that the students be especially safety conscious as they will be working with a hot plate and melted wax.

Each group should line their remaining two pie pans with aluminum foil and do the following:

Groups 1 and 2 should each fill one of their pie pans with crushed ice.

Group 3 should fill one of its pie pans halfway with water.

Group 4 should place the "weathered fragments" and the smaller pieces of "sedimentary" and "metamorphic" rocks (saved earlier) into one of the foil-lined pie pans. (Groups 1, 2, and 3 will save their fragments and "rock" pieces for comparison with the "igneous rocks" they will make during this part of the activity.)

For the igneous rock simulation, all groups should place the "weathered sediments" they set aside in envelopes, plus the larger piece of "metamorphic rock," into one of their foil-lined pie pans.

Be especially careful here! This part of the activity requires a hot plate as a heat source. *Students should avoid dropping wax fragments on the hot plate surface or themselves*. The students or teachers doing this portion of the activity should wear protective oven mittens to avoid being burned. Cover each hot

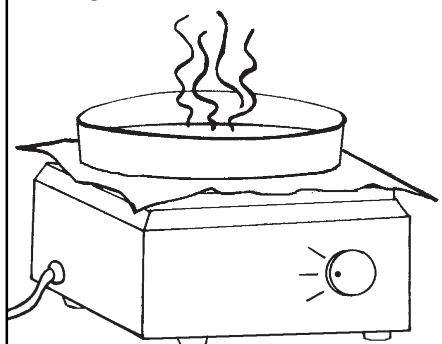


plate surface with a layer of foil before you turn it on. (This will diffuse the heat from the coils of the hot plate so the crayons will not burst into flames.) Each group should place their pie pan of "weathered sediments" and "metamorphic rock" on the hot plate and turn the hot plate temperature to medium. Melt the wax, being careful that the melting process does not occur so rapidly that the molten wax splatters or burns. When most of the "rock" and "weathered sediments" are in the molten state, turn the hot plate off and carefully remove the pie pan, using the oven mittens. There is enough heat energy in the molten wax to melt the remaining solid mass. *Caution: Do not let the wax heat to the splattering point!*

While the wax is still in the molten state, representing magma, a student from each group, or the teacher, should *carefully* do the following:

Group 1 - Form a trench in the ice, and using the oven mittens, pour the melted wax into the ice trench. Then cover the "**magma**" with more crushed ice. This simulates **intrusive igneous rock**, which is formed by magma flowing into rock cracks deep inside the earth.

Group 2 - Using the oven mittens, pour the melted wax (lava) directly over the surface of the crushed ice. This simulates the formation of **extrusive igneous rock**.

Group 3 - Using the oven mittens, pour the melted wax into the water. This simulates the formation of extrusive igneous rock into an ocean, e.g. a **volcano** that spews lava into the ocean.

Group 4 - Using the oven mittens, pour the melted wax over the "weathered sediments" and the small pieces of "sedimentary" and "metamorphic" rock from Parts B and C. This simulates **lava** flowing over sediments and rocks, as would happen in a **volcanic eruption**. Some of the rocks will melt quickly, while others will at least partially maintain their integrity. The rocks that are surrounded by lava are called **xenoliths**. Note that xenoliths can also occur in intrusive igneous rocks, when magma surrounds, but does not entirely melt parts of an existing rock. If your class visits Stone Mountain, look for xenoliths (dark clumps in the lighter-colored granodiorite rock).

Allow the pie pans and wax to cool thoroughly (about 5 to 10 minutes). After the "lava" wax has cooled, the students should carefully remove their "igneous rock" from the pie pans. Students should make comparisons between the igneous rock in each group's pie pans, then draw and write their observations on their worksheets. Comparisons should also be made between these "igneous rocks" and the "sediments" and the "sedimentary and metamorphic rocks" students created in the previous sections of this activity. As a class be sure to discuss the following:

Using Group 1's pie pan, discuss the effect of the "magma" on the sedimentary or metamorphic "rock" that the ice represents.

Using Group 2's pie pan, discuss the effect of "lava" on the surface "sediments" and "rocks" that the ice represents.

Using Group 3's pie pan, discuss the effect of the water on the "lava."

Using Group 4's pie pan, discuss the effect of the "lava" flowing directly onto the sedimentary and metamorphic "rock" and "sediments."

If possible, show the students various examples of real volcanic rocks and compare the real rocks with the "igneous crayon rocks." Remind the students that most of the rock visible at Stone Mountain State Park is igneous in origin. These rocks formed deep within the earth. Most of the rock is still buried; however, the processes of weathering and erosion have exposed the top part on and around Stone Mountain.

While the students are looking at the three types of rocks, lead a discussion on the rock cycle, focusing on the processes they observed to transform one rock into the next. Have the students discuss the differences and similarities between their "crayon rocks" and the real rock samples. Talk about the questions your students had when the activity first started.

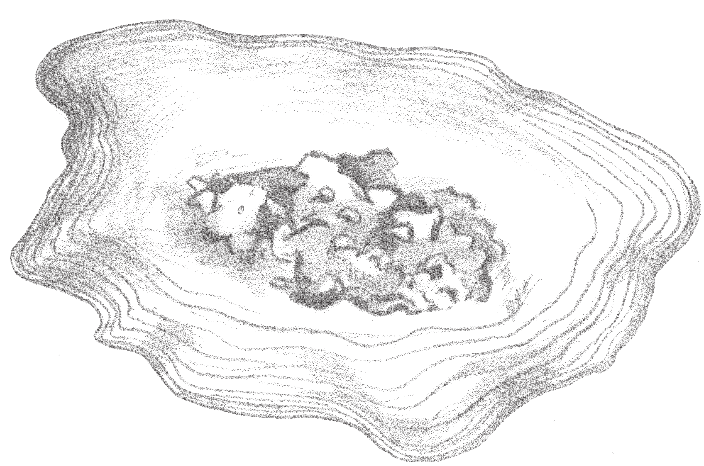
Reiterate the concept of the rock cycle by reminding the students of the "rocks" (crayons) that were weathered down into "sediments," compressed into "sedimentary rocks" and then "metamorphic rocks," and finally melted into "igneous rocks."

It is important for everyone to understand that not all conditions for rock formations can be simulated. In fact, geologists have never "seen" intrusive rocks form. However, they are able to look at the available evidence, simulate some of the conditions in the laboratory, and arrive at results similar to those found in nature.

Assessment:

Remove the words written in the arrows on the Rock Cycle Diagram, then copy for each student. With younger students, list the following five terms on the chalkboard or overhead: compaction, melting, cooling, erosion, and heat & pressure. Ask students to label the arrows on the Rock Cycle Diagram.

With older students, ask them to label the diagram, then explain in their own words how each of the three rock types formed. Can they relate the rock cycle and the three main rock types to the geological history of Stone Mountain?



Student's Information

Rocks are classified according to their origin. The three basic rock classes are **igneous**, **sedimentary** and **metamorphic**. Igneous and metamorphic rocks are formed by **geologic processes** occurring deep within the **earth's crust**. Sedimentary rocks are formed closer to the earth's surface. Most of the rock that you can see in and around Stone Mountain is igneous. However, throughout the rest of the park, and in the area surrounding the park, the primary rock type is metamorphic. Let's learn more about the three rock types and how they relate to the park's geology.

1. **Sedimentary rocks**

All sedimentary rocks are composed of tiny particles of sand, clay or other **sediments** that are deposited in layers on the bottom of lakes, rivers and oceans, or on land. Sedimentary rocks are the "parent rocks" for most of the metamorphic rocks we see in the Blue Ridge Mountains today.

Over 700 million years ago, sediments were laid down in an ancient ocean, which was the forerunner to the present Atlantic Ocean. Over time, the extreme pressure from the weight of the layers above pressed the sediment into rock, or in some cases, the sedimentary particles were cemented together. Examples of sedimentary rocks formed in this way are **sandstone, siltstone** and **shale**.

2. **Metamorphic rocks**

The word ***metamorphosis*** means a transformation, a marked change in appearance or condition. A familiar example would be a caterpillar changing, or metamorphosing, into a butterfly. Rocks are metamorphosed when they are exposed to tremendous heat and pressure, yet do not actually melt.

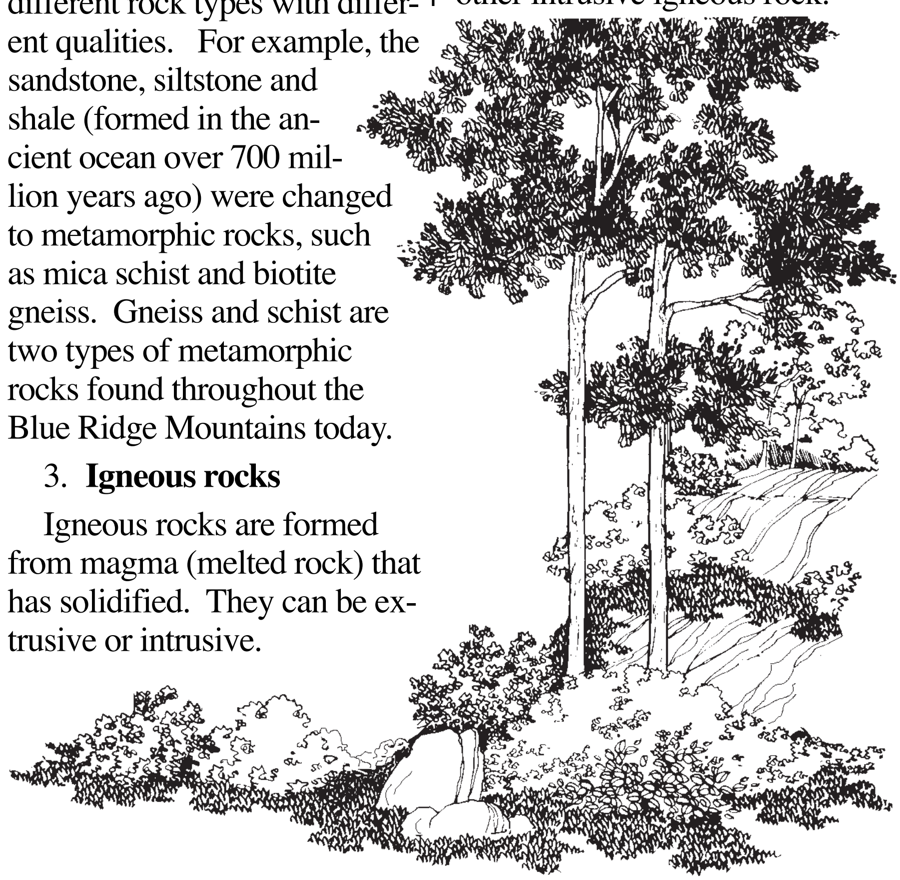
From 450 to 250 million years ago, the continents of Africa and North America moved towards each other and eventually collided. The rocks involved in this collision were exposed to extreme temperatures and pressures. As a result, many of the rocks metamorphosed, or changed into different rock types with different qualities. For example, the sandstone, siltstone and shale (formed in the ancient ocean over 700 million years ago) were changed to metamorphic rocks, such as mica schist and biotite gneiss. Gneiss and schist are two types of metamorphic rocks found throughout the Blue Ridge Mountains today.

3. **Igneous rocks**

Igneous rocks are formed from magma (melted rock) that has solidified. They can be extrusive or intrusive.

Extrusive igneous rocks are formed when magma spews out onto the earth's surface from cracks or **vents** in the earth's crust. This type of magma is called **lava**. **Intrusive igneous rocks** are formed when magma pushes its way up into cracks in the earth's crust, but solidifies within the earth. A body of intrusive igneous rock is called a pluton.

The Stone Mountain pluton solidified deep in the earth about 390 million years ago as the continents of Africa and North America moved closer together. The specific type of rock in the Stone Mountain pluton is **granodiorite**. It is very similar to **granite**, another intrusive igneous rock.



However, granodiorite contains *less* potassium feldspar (orthoclase) and *more* of the sodium-rich plagioclase feldspar. Usually, granodiorite also has more dark-colored minerals, such as biotite or hornblende.

The Rock Cycle

The relationship between the three rock classifications is described as the **rock cycle**. Geologists believe that at one time the earth was a ball of molten magma and gases. As the earth cooled, the outermost layer of magma solidified into a crust of igneous rock. Today, the earth's crust is 30 miles thick in some places, yet in others it is so thin that lava can spew up through cracks.

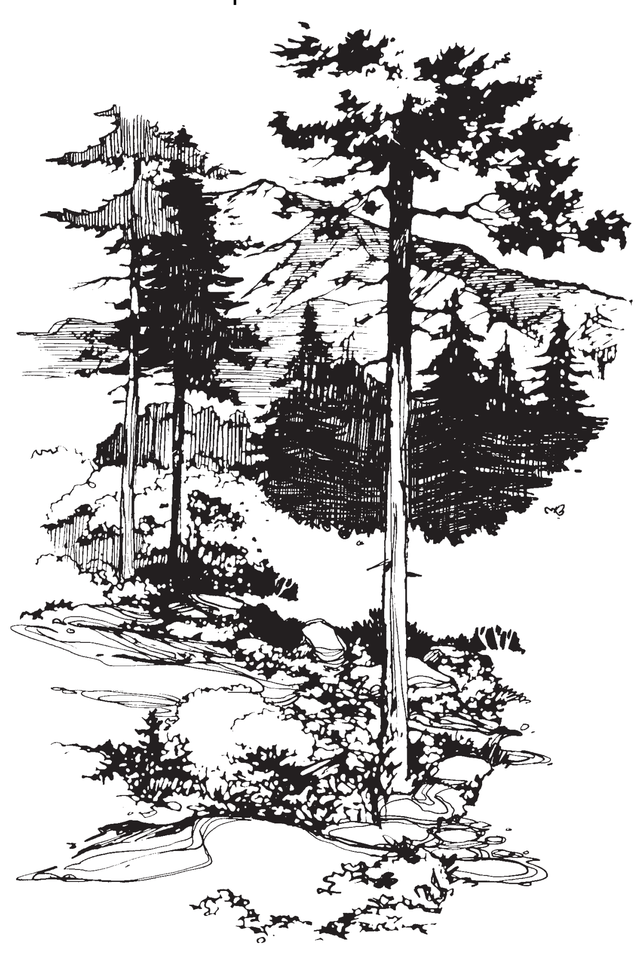
Even as the first rocks cooled, **weathering** began breaking them down into sediments that were eroded away by wind and water. Those first sediments were deposited at the edges of the continents in the first oceans. The eroded rock particles traveled more quickly than they do today, as there were no plants to stabilize the loose soil. For over three billion years the continents were bare rock and sediments.

The sediments continued to build up as the continents wore down. The underlying sediments became rock again as the pressure and heat cemented the particles back together. Often, as the continents eroded they became lighter and rose up, exposing the sedimentary rocks to the air, where they started to erode away once again. Most of the earth's crust is made up of igneous rock, but the most common class of rock found on the earth's continental surface is sedimentary, which lies on top of the igneous crust.

The crust is divided into many large crustal plates that slowly drift about on top of the denser "plastic" **mantle**, which lies beneath the crust. As the plates move around, sometimes the crust at the leading edge of one plate slides underneath the edge of an adjacent plate. This pushes the crust down far enough that it melts, turning into magma. Volcanic activity such as that shown by Mt. St. Helen's can result.

When two continents collide, the crust is folded into mountain ranges. For example, the Himilayas were created when India collided with the southern edge of Asia. This collision caused the rocks caught in it to be put under tremendous heat and pressure, so that they metamorphosed. Eventually this metamorphic rock reaches the earth's surface where it is subjected to weathering.

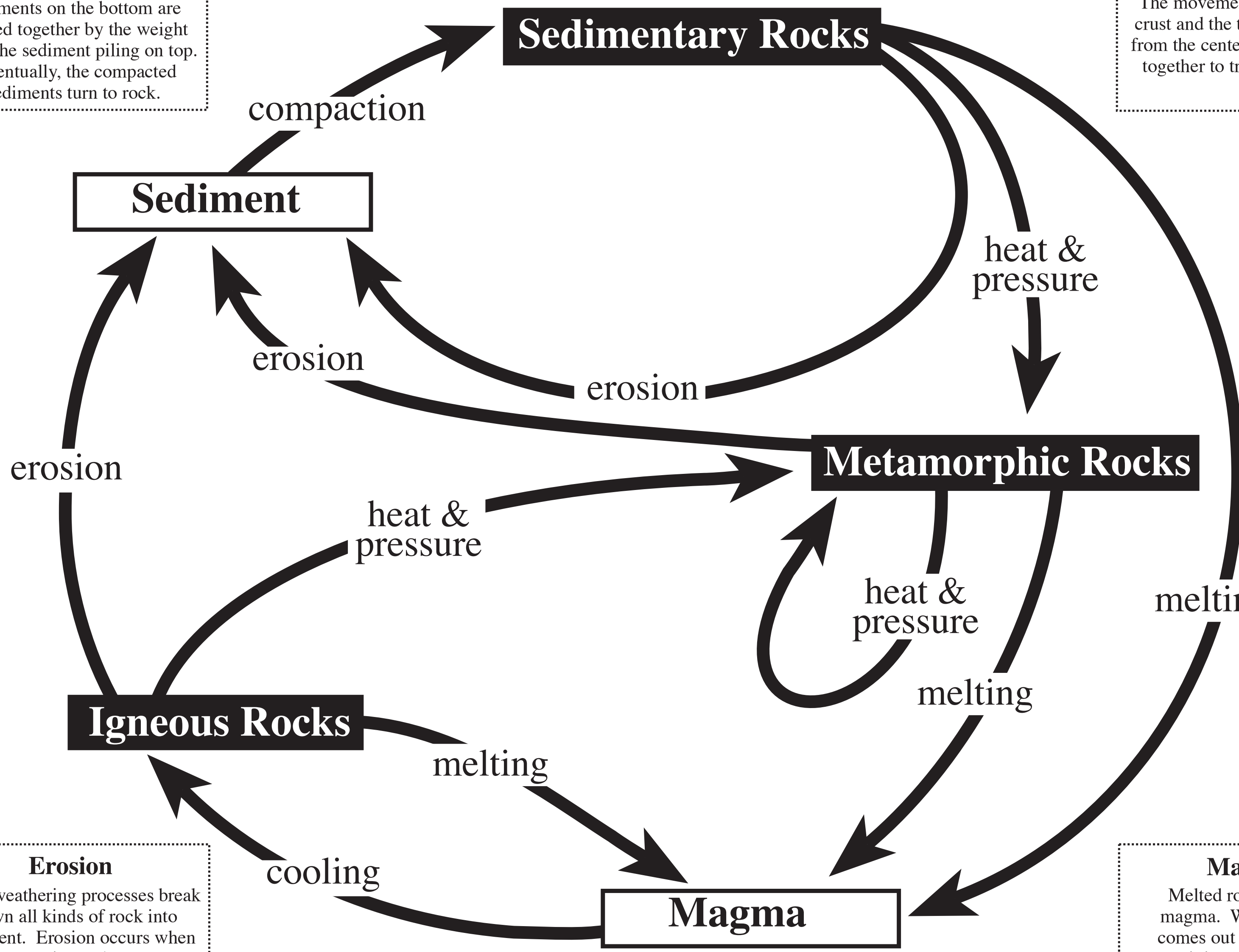
The continuing cycle of rocks melting and cooling into rocks again, or breaking down and being pressed into rocks again, or being put under pressure and metamorphosing into new rocks has happened many times on earth. It's happening today and will continue to occur on our ever-changing planet.



Rock Cycle Diagram

Compaction
As sediments pile up, those sediments on the bottom are packed together by the weight of all the sediment piling on top. Eventually, the compacted sediments turn to rock.

Heat and Pressure
The movement of the earth's crust and the tremendous heat from the center of the earth act together to transform rocks.



Erosion
First, weathering processes break down all kinds of rock into sediment. Erosion occurs when wind, water, ice and snow carry these sediments away.

Magma
Melted rock is called magma. When magma comes out of a volcano, it is called lava.

"The Pressure's On" Worksheet

1. Describe and draw the "weathered sediments" that you made. Note the sizes and shapes of the "sediments."

2. Do a colored drawing of the "rock fragments" after light pressure has compacted these "sediments" into "sedimentary rock." Describe the broken edge and the layers that are formed.

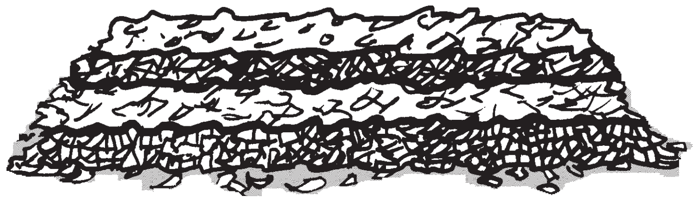
3. Do a colored drawing of the "sedimentary rock" after heavy pressure has compacted it into "metamorphic rock." Describe the broken edge and the layers that are formed. How have they changed with the addition of heavy pressure?

4. Do a colored drawing of each of the four "igneous rocks" created. Compare and contrast the formation of the extrusive with the intrusive "igneous rocks."	
Group One's "Igneous Rock" (intrusive)	**Group Two's "Igneous Rock"**
Group Three's "Igneous Rock"	**Group Four's "Igneous Rock"**

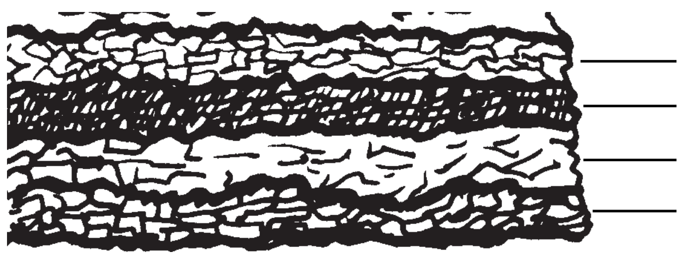
5. Write a comparison between the "weathered rock fragments," "sedimentary rocks," "metamorphic rocks," and "igneous rocks" formed in this activity. Describe their similarities and differences as to color, texture, etc.

“The Pressure’s On” Answer Sheet

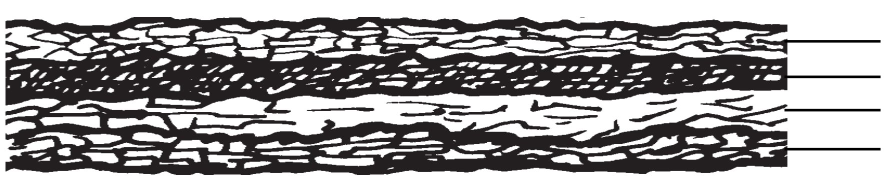
1. Describe and draw the “weathered sediments” that you made. Note the sizes and shapes of the “sediments.”



2. Do a colored drawing of the “rock fragments” after light pressure has compacted these “sediments” into “sedimentary rock.” Describe the broken edge and the layers that are formed.



3. Do a colored drawing of the “sedimentary rock” after heavy pressure has compacted it into “metamorphic rock.” Describe the broken edge and the layers that are formed. How have they changed with the addition of heavy pressure?



4. Do a colored drawing of each of the four "igneous rocks" created. Compare and contrast the formation of the extrusive with the intrusive "igneous rocks."

Group One's "Igneous Rock" (intrusive)	**Group Two's "Igneous Rock"**
Group Three's "Igneous Rock"	**Group Four's "Igneous Rock"**

5. Write a comparison between the "weathered rock fragments," "sedimentary rocks," "metamorphic rocks," and "igneous rocks" formed in this activity. Describe their similarities and differences as to color, texture, etc.

The "weathered rock fragments" will vary in size and shape, depending on the implement used and how it is used. The "rock fragments" can be oriented (up/down or right/left) in any direction. In the "metamorphic rocks" the space between the fragments is very small and the orientation of "fragments" is now flattened (right/left). The thickness is much thinner, but each layer of rock (color) can still be seen. The "igneous rock" is grayish-black due to the melting and mixing of different "rock fragments" and has a variety of forms, depending on how the separate groups' rocks were cooled.

Note: The different methods of cooling are not intended to simulate real rock formations. They do, however, give the students the understanding that different cooling conditions will create different rocks.

Pre-Visit Activity #2 Let's Do the Time Warp

Major Concepts:
- Geologic history
- Geologic time

Learning Skills:
- Observing, inferring, using models
- Organizing and expanding information; creating a product
- Measuring

Subject Areas:
- Science
- English Language Arts
- Mathematics

* See the **Activity Summary** for a Correlation with DPI objectives in these subject areas.

Location: Classroom

Group Size:
30 students, class size

Estimated Time:
2 - 3 class periods

Appropriate Season: Any

Materials:
Provided by the educator:
A 25' long continuous strip of 18" wide freezer paper, measuring stick, markers or crayons, tape, reference books on fossils and life during the various geologic time periods
Per student: Geologic Time Fact Sheet and the Events in Geological History chart

Objectives:
- List the four units of geologic time.
- Conceptualize geologic time using a mural model.
- Name the epoch, period and era in which we live.
- Name the period and era in which the Stone Mountain pluton was formed.

Educator's Information:

Geology is the science of the earth and its history. When we study geological history, we find that water invaded the land, layers of **sediment** were deposited, the land was pushed up into mountains and eventually wind, rain and ice leveled the land again. This sequence has been repeated many times over the history of the earth.

It is quite difficult for most of us to understand the concept of **geologic time**. Because we tend to regard events on our planet using a time scale of hours, days, months and years, it is easy to underestimate the vast amount of time covered during an **eon** like the Proterozoic.

By creating a visual model, the students should begin to more clearly understand the broad scope of geologic time. The mural model described in this activity begins with the Late Proterozoic era and ends with today's Holocene epoch.

Note: The term *Precambrian* is sometimes used to describe rocks older than 544 million years. Precambrian is a time term without specific rank. In this EELE, we use the more specific term, *Late Proterozoic era*, to refer to earth's history from 544 to 900 million years ago.

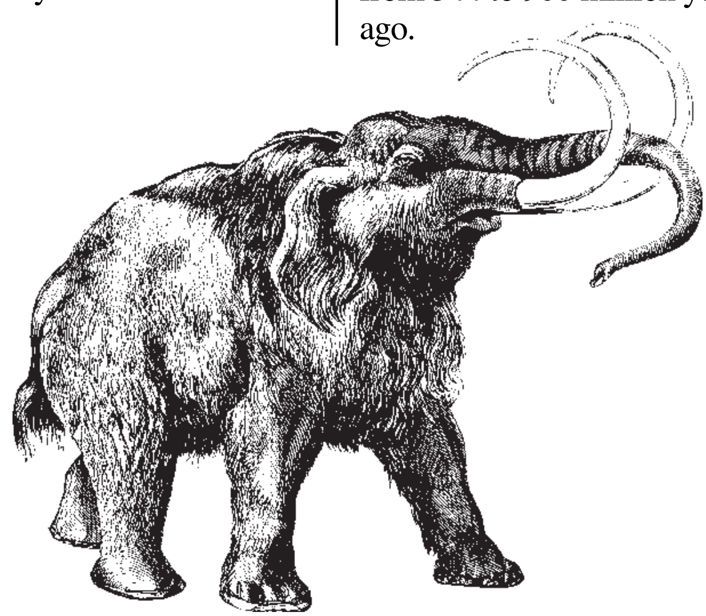
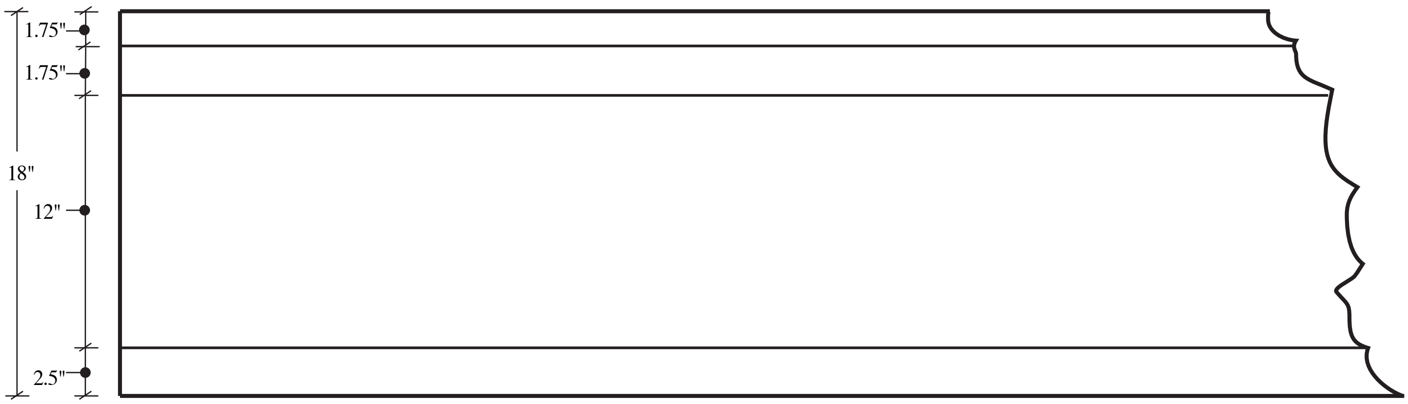


Figure A



Instructions:

1. Run a continuous strip of freezer paper along the wall in the classroom. The paper should be at least 21 feet in length. (Note: Spiral the paper around the room if needed.)

2. Using a yardstick and a black marker or crayon, have the students draw a continuous line, 2.5 inches up from the bottom of the paper, along the entire length of the paper. If a marker is used, make sure it will not "bleed through" onto the classroom wall.

3. Have the students draw a second continuous line with the marker or crayon 12 inches above the first line.

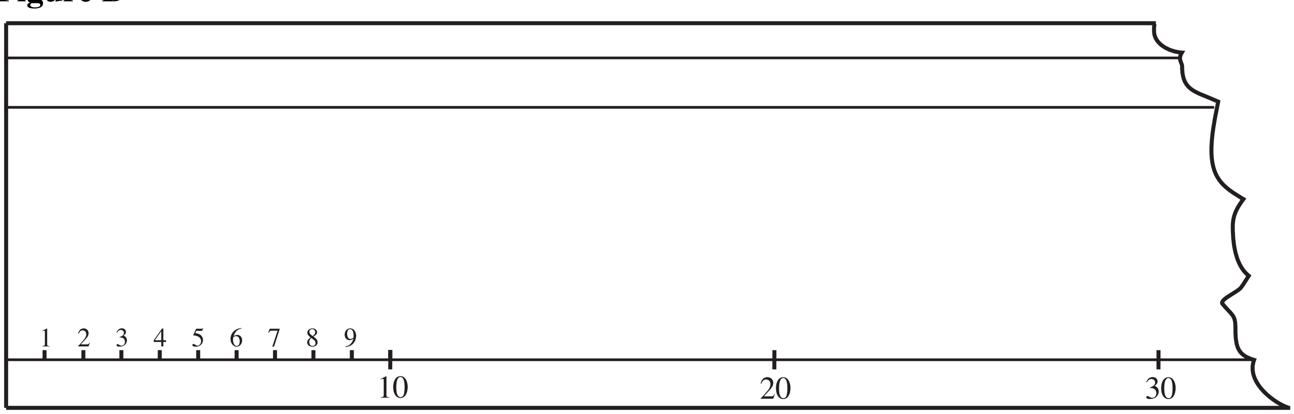
4. Have the students make another continuous line 1.75 inches above the line drawn in step 3. After steps 1-4, the paper should look similar to Figure A.

5. Using the marker or crayon, have the students place 61 marks, four inches apart, on the paper below the bottom line. Starting with the second mark, have them label the marks by 10 mya (million years ago) intervals, giving a total representation of 600 million years.

Also, divide the space from 0 to 10 mya into 10 one-million-year segments. Label these segments 1 to 9. After step 5, the paper should look like Figure B.

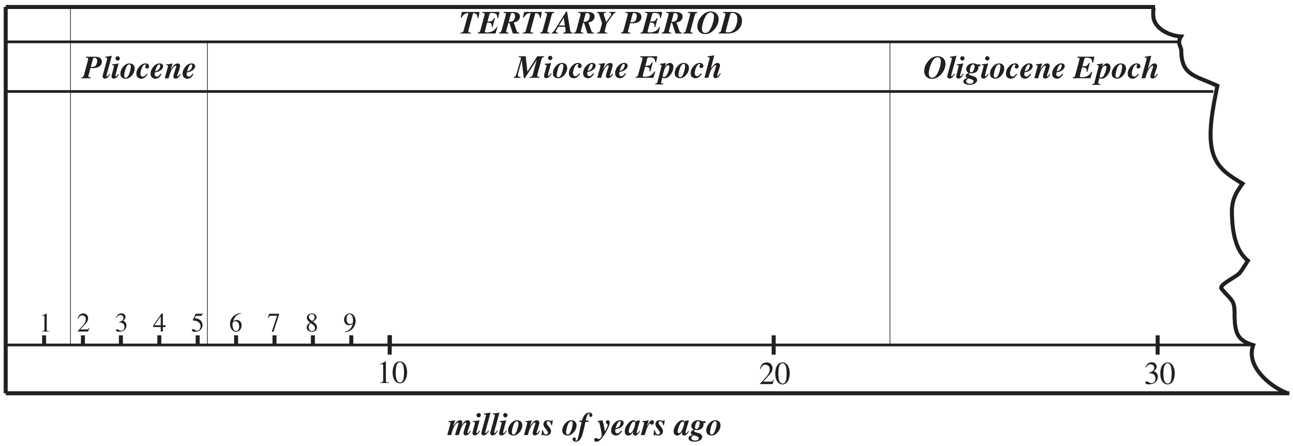
6. This geologic time activity provides information on 12 **periods** and seven **epochs**. Divide the class into four teams. The whole class will be responsible for depicting the Phanerozoic eon.

Figure B



millions of years ago

Figure C



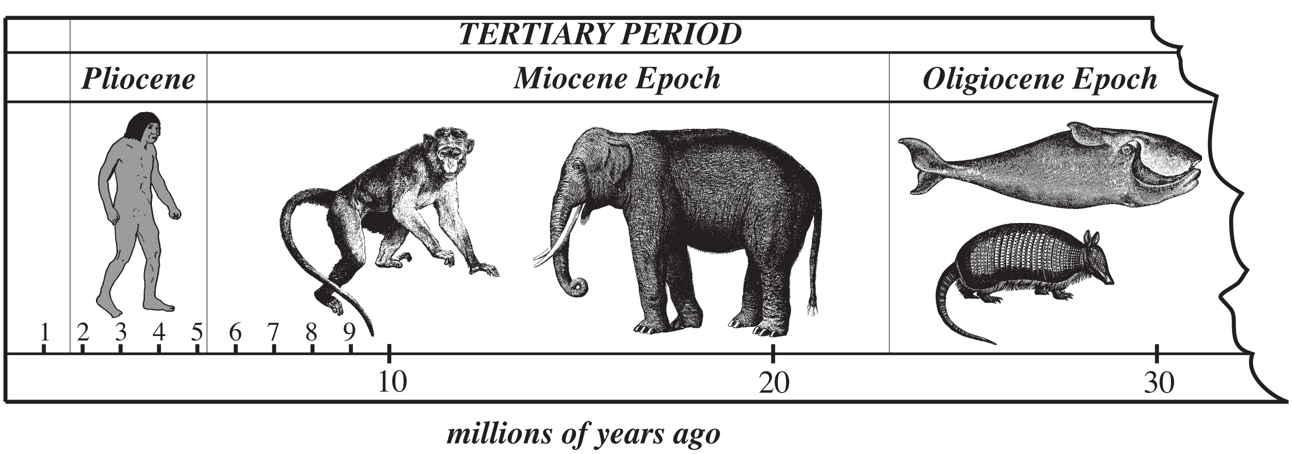
Each team should be assigned three periods to illustrate from the Geologic Time Fact Sheet (on page 3.2.5). The team that has the Quaternary and Tertiary periods should also portray the related epochs. Each team is responsible for finding its periods or epochs on the time scale mural and marking them off with vertical lines, being sure to label the time periods (See Figure C). Note that different references do not always agree on the exact beginning and ending for each period. The geologic time scale in this EELE includes the latest information from the North Carolina Geological Survey.

The teams will also illustrate what animals and plants lived during their assigned periods. Students working within the 0 to 10 mya scale (Quaternary period) will not have room to place their illustrations. They can use arrows to indicate where their illustrations fit into the main scale on the paper. The students can do some independent research (beyond pages 3.2.6-3.2.9) if they are not familiar with the animals and plants found in their time periods. After step 6 the mural should resemble Figure D.

7. In the space remaining on the mural, students can illustrate geologic events over the appropriate years. Use the Geologic Time Fact Sheet (page 3.2.5), Events in Geological History (pages 3.2.6-3.2.11), and library references as guides.

8. After the students have completed the timeline mural, remind them that when studying geology, it is often difficult to determine absolute ages. Therefore, geologists use geological **eras** and

Figure D



periods when discussing the earth's history rather than calendar dates. This mural illustrates the vast number of years our earth's history covers since the formation of Stone Mountain.

9. Compare the student's life history (years of age) with the history and age of Stone Mountain. Be sure to note what era, period and epoch we live in.

10. The Abbreviated Events in Geological History (page 3.2.12) is a simplified overview of the geological history of the earth. Geologic events related to the formation of Stone Mountain are highlighted. Use this page with younger students, or to quickly give the "big picture."

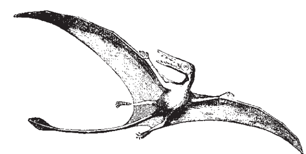
Assessment:

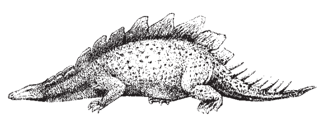
1. Scramble the events on the Abbreviated Events in Geological History chart. Can students place them in the correct sequence?

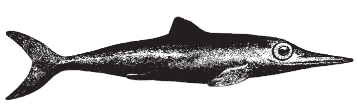
2. Pencil and paper quiz: Write *period*, *eon*, *era* and *epoch* on the board or overhead. Ask students to put the names of these four units of geologic time in order of largest unit to smallest. Ask them to write down the name of the period, eon, epoch and era in which we are currently living. Finally ask them to write the name of the geological period in which the Stone Mountain pluton was formed. About how many millions of years ago was this?

Extension:

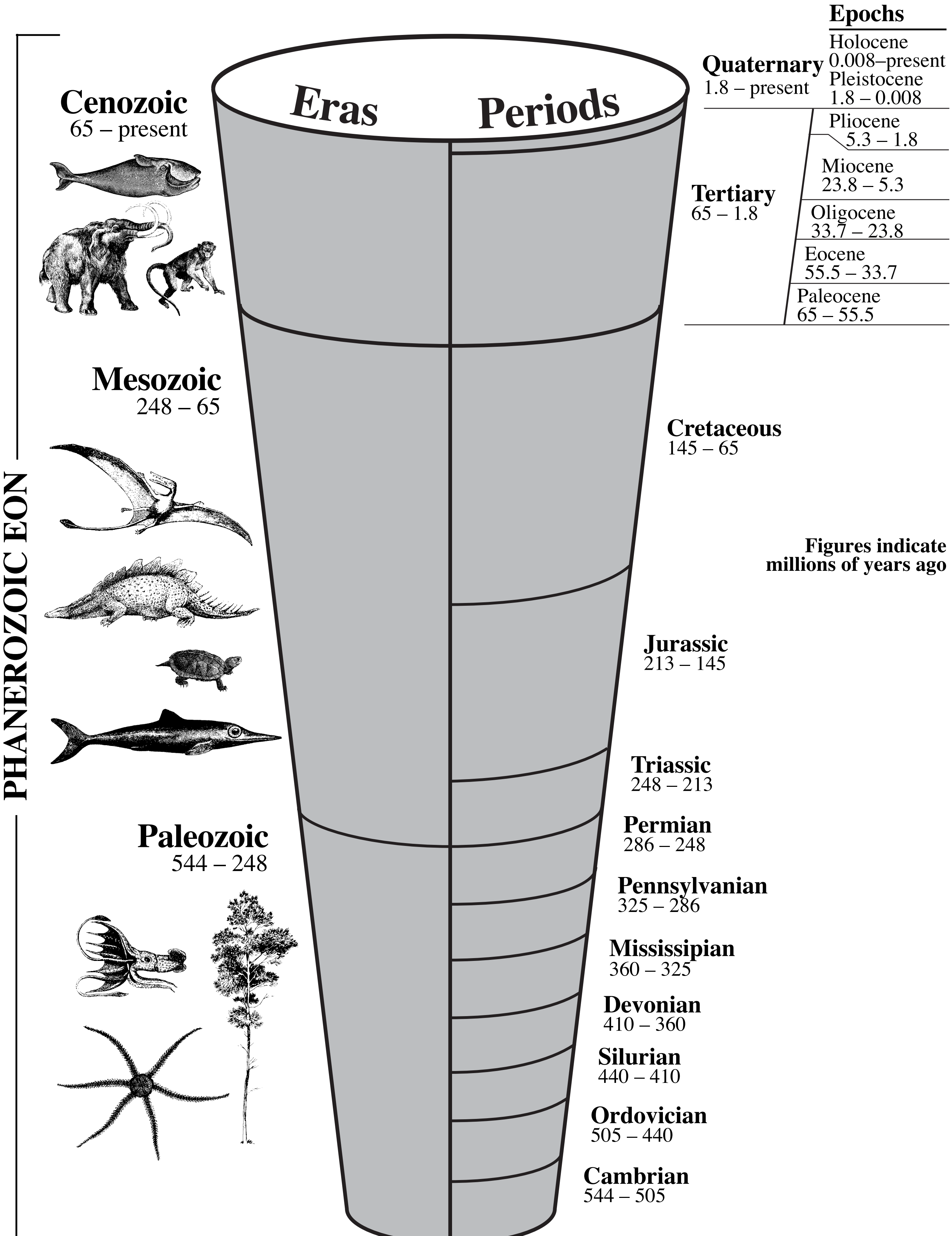
Using reference books, encyclopedias, field guides, etc., search for other earth history events not listed in the Events in Geological History in this EELE and include them in the mural. High school students could assess the evidence for major geologic events and paleoclimatic changes.







Geologic Time Fact Sheet



Information courtesy of N.C. Geological Survey

Geologic Time Fact Sheet

Time is an important concept in geology. **Geologic time** includes all the time that has occurred since the formation of the earth – an estimated 4.5 billion years ago. These 4.5 billion years have been broken down into different **eons**, **eras**, **periods** and **epochs**. Eons are subdivided into eras; eras are subdivided into periods; and periods are further subdivided into epochs.

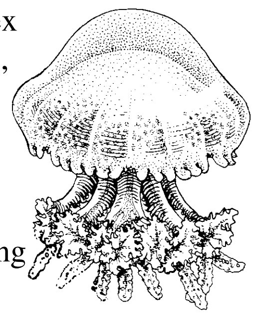
Each of the units of geologic time is characterized by different environmental conditions and specific kinds of life that flourished. Often, the boundaries between the geologic time periods were marked by mass extinctions. Geologists continue to study rock formations today to put together a more accurate history of our planet.

Note: The earth's history is divided into four eons: Phanerozoic, Proterozoic, Archean and Hadean. Because there are no ancient rocks from the Archean or Hadean in North Carolina, we will concentrate on the two more recent eons – Phanerozoic and Proterozoic.

PROTEROZOIC EON...

2.5 billion years ago to 544 million years ago

The Proterozoic eon is divided into three eras: Early, Middle and Late. The oldest known rock in North Carolina (Roan Mountain) dates to the Early Proterozoic (1.8 billion years old). By the beginning of the Proterozoic, blue-green algae had evolved and photosynthesis had begun. The oxygen produced during photosynthesis changed the earth's atmosphere, enabling the evolution of more complex life. Sponges, soft corals, jellyfish and annelid worms also evolved during this eon.



During the Late Protoerozoic, sediments accumulated in an ancient ocean, which was the forerunner of today's Atlantic Ocean. These sediments would later form the sedimentary rocks that are the "parent rocks" to those found in the Alligator Back Formation near Stone Mountain State Park.

PHANEROZOIC EON...

544 million years ago to the present

PALEOZOIC ERA

"Age of Ancient Life"
544 million to 248 million years ago

Cambrian Period

544 to 505 million years ago

This period marks the first appearance of fossil shells. The most common shelled animal of this time was the trilobite. Trilobites were probably scavengers on the ocean floor. All life lived in the ocean during this period, because the earth's atmosphere had not yet developed to protect the land from the ultraviolet radiation of the sun. Along with the trilobites, there were sponges, brachiopods (bivalve mollusks) and gastropods (one-shelled mollusks). At the end of the Cambrian, 75 percent of all the trilobite families, 50 percent of the sponge families and many of the brachiopods and gastropods disappeared. No one knows what caused this mass extinction.

Ordovician Period

505 to 440 million years ago

During this period, the tectonic plates carrying the continents of Africa and North America began to move towards each other. The sedimentary rocks formed during the Late Proterozoic era were folded and metamorphosed as the ancient ocean basin closed.

Also during the Ordovician period, a few very primitive plants evolved to live on land. However, most life forms were still evolving in the oceans. Bivalves, like clams and oysters, developed during this period, along with most of the other invertebrates (animals without a backbone). Starfish, brittle stars, hard corals and crinoids were some of these invertebrates. Very primitive, jawless fishes also developed during this period. Fish are one kind of vertebrate, or animal with a backbone. A mass extinction ended this period, when many of the remaining trilobites and some of the early fish and sponges died out.

Silurian Period

440 to 410 million years ago

This period is marked by the development of extensive coral reefs in the ocean. No new major forms of life developed during this period. All of the life that had previously evolved continued to flourish with the exception of the trilobite, which continued to become rarer. Millipedes and scorpions may have begun to live on the land.

Devonian Period

410 to 360 million years ago

During this period, North America and Africa continued to move closer together. Magma generated deep in the earth from the continental collision moved upward and formed the plutons of igneous rock found today at Stone Mountain, Mt. Airy and Spruce Pine.

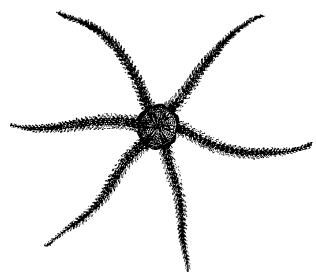
The Devonian period is also called the Age of Fishes because the early, primitive forms of fish multiplied and diversified – sharks, rays and bony fishes. A giant, 30-foot long fish called the Dunkleosteus did not have any teeth, but the bones in its jaw were as sharp as knives.

Other invertebrates began to live in fresh water during this period. The first amphibians, vertebrate animals that live part of their life in water and part on land, evolved. The first forests with giant horsetails and tree ferns were found during the Devonian period. The first seed-bearing plants also evolved then. Mass extinction marked the end of this period – 25 percent of all species disappeared.

Mississippian Period

360 to 325 million years ago

During this period almost all of North America was covered by oceans. Crinoids, feather stars and sea lilies flourished in the oceans. The trilobites continued to decline.



Pennsylvanian Period

325 to 286 million years ago

The Pennsylvanian period was a time of mountain building and the loss of many of the shallow seas. Africa and North America collided and became part of the supercontinent known as **Pangaea**.

During this period, many of the marine species declined, but the first insects and reptiles evolved. The largest insect that ever lived, a dragonfly with a wingspan of 29 inches, lived during this time. Most of the land was covered with swampy forests. Conifers first developed during the Pennsylvanian period.

Permian Period

286 to 248 million years ago

During the 38 million years of the Permian period, the marine invertebrates specialized into many different forms. The ginko tree first appeared. Reptiles and amphibians continued to develop. One of the most important groups of reptiles from this period was the pelycosaurs, ancient forerunners of the mammals. Each pelycosaur had a tall, sail-like projection on its back that was supported by spines from its backbone. The sail was probably used to help heat and cool its body. This period ended with the most severe of all mass extinctions – 96 percent of all species were lost.

MESOZOIC ERA

"Time of Middle Life"

248 to 65 million years ago

Triassic Period

248 to 213 million years ago

During the Triassic period, the supercontinent Pangea began to break apart. Africa separated from North America and the Atlantic Ocean began to form. At the same time, rift basins, large cracks in the earth's crust, developed along the eastern side of the mountains from New England to Florida.

At the beginning of the Triassic, there was very little marine life left after the mass extinction that ended the Permian period. The first modern corals developed. The entire

Mesozoic era is known as the Age of Reptiles because the reptiles developed to dominate the air, land and sea. The first dinosaurs appeared near the end of the Triassic. These dinosaurs were the saurichians, which walked on two feet and had stabbing teeth. Crocodiles also appeared at the end of the Triassic. Lizards, turtles and marine reptiles, like the plesiosaurs, also evolved in the Triassic. Finally, the first mammal, a small mouselike animal that ate insects, evolved. The Triassic ended with a mass extinction in which 25 percent of all species became extinct.

Jurassic Period

213 to 145 million years ago

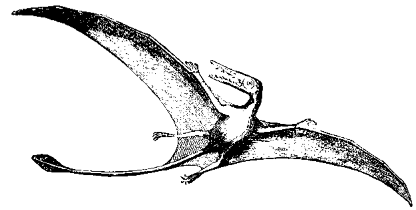
Oysters, crabs, lobsters, sea urchins and shrimps developed in the oceans. The stegosaurus and the pterosaurs (flying reptiles) appeared during this time. The mammals were still quite small, but more diverse. The Jurassic period marks the evolution of the first bird. Insects continued to become more diverse.

Cretaceous Period

145 to 65 million years ago

The Atlantic Ocean continued to widen. Weathering and erosion began to reduce the height of the once-lofty Appalachian mountains. The rock formation that we call Stone Mountain today may have just begun to be exposed at the earth's surface.

Much of the land was covered by shallow seas. Pterosaurs, the flying reptiles, became more specialized. Some of the Cretaceous dinosaurs include tyrannosaurs, ankylosaurs and the duck-billed dinosaurs. Flowering plants, bees and butterflies also evolved during this time. The end of the Cretaceous was marked by a mass extinction, second only to the extinction that marked the end of the Permian. All of the dinosaurs went extinct, along with marine reptiles, pterosaurs, many corals, sponges and other marine invertebrates.



CENOZOIC ERA

"Time of Recent Life"

65 million years to present

Tertiary Period

65 to 1.8 million years ago
(Five Epochs)

Paleocene Epoch

65 to 55.5 million years ago

Much more dry land was exposed as the seas dried up during the Paleocene or "old recent life" epoch. The entire Tertiary is known as the Age of Mammals because many different kinds of mammals developed during the 63 million years of this period. Along with the development of hoofed mammals, rodents, and squirrel-like primates on land, sharks were abundant in the oceans.

Eocene Epoch

55.5 to 33.7 million years ago

Eocene means the dawn of recent life. Mammals continued to diversify, giving rise to whales, sea cows, bats, early horses and rhinoceroses.

Oligocene Epoch

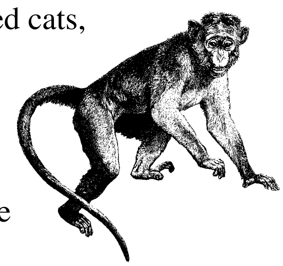
33.7 to 23.8 million years ago

Oligocene means "few recent (kinds of life)." Dogs, rats, camels, cats and pigs all multiplied during this time. Sloths, armadillos and guinea pigs all evolved separately in South America.

Miocene Epoch

23.8 to 5.3 million years ago

The "less recent" epoch lasted for 19 million years. Saber-toothed cats, elephants, apes, monkeys, giraffes and cattle are some of the mammals that evolved and multiplied during this epoch.



Pliocene Epoch

5.3 to 1.8 million years ago

The vegetation of the Pliocene was much like today's. Australopithecines, the ancestors of humans, evolved during the Pliocene. The mammals that had evolved during the other epochs continued to multiply and spread throughout the earth.

Quaternary Period

1.8 million years ago to the present (Two Epochs)

Pleistocene Epoch

1.8 million to 8,000 years ago

There were at least four glacial advances during the Pleistocene epoch, or Ice Ages. Most notably during this epoch, *Homo sapiens*, or humans, evolved – probably in Africa. During the Ice Ages, wooly mammoths, mastodons, and wooly rhinoceroses were common. During the warmer periods, giant ground sloths, saber-toothed cats, lions, wolves, bison, camels, cattle and horses were common. Many of the large mammals went extinct at the end of this epoch. Some scientists think that it may have been due to hunting by the early humans, but no one knows for sure.

Holocene Epoch

8,000 years ago to present

The climate of the present epoch is much warmer than the climate of the Ice Ages. Humans may be playing a role in this global warming. The human population continues to expand. Humans are playing a greater role in causing extinctions, particularly in the rain forest regions of the world.

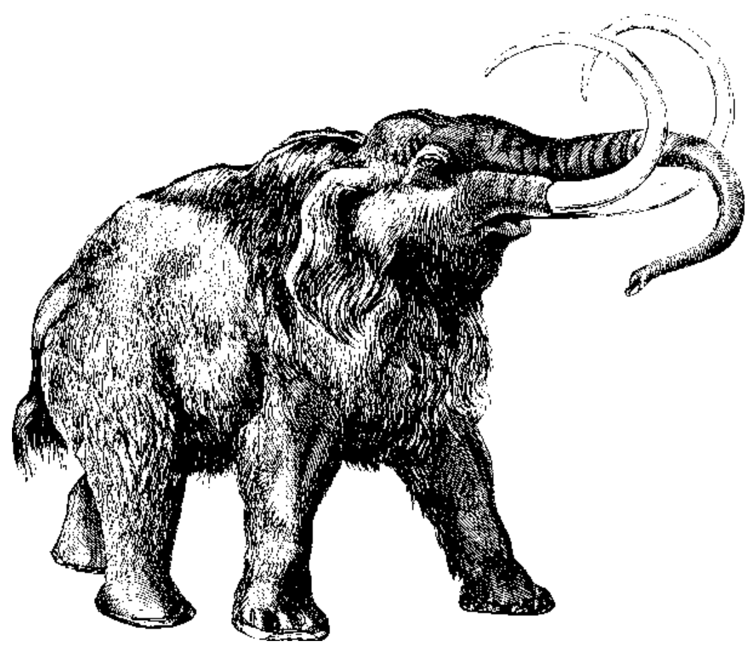
How do geologists determine the age of a rock formation?

They use two methods: relative dating and absolute dating.

Absolute dating is used for metamorphic rocks and igneous rocks, such as the granodiorite at Stone Mountain. This method is based on the natural decay of radioactive elements found in some rocks. As a radioactive element decays, it changes into a different element (a breakdown product). This decay rate is constant over time and can be observed and measured in the laboratory. Knowing the decay rate for a given element, geologists can calculate the approximate age of a rock. They measure the amount of the original radioactive element still left in the rock and compare it to the amount of the breakdown product found in the rock. This technique can provide an approximate date for when an igneous rock, such as granodiorite, crystallized from magma.

Relative dating is much less precise and depends on the relationships between rocks. For example, in undisturbed sedimentary rocks, the *oldest* layer is always found at the bottom. And, rock units that cut across, or intrude into other rocks are *younger* than the rocks they cut into. Geologists also use fossils in sedimentary rocks to help them determine the relative ages of these rocks. Rocks that have the same or similar fossils are most likely the same age.

Using relative and absolute dating, geologists can piece together a geologic history of the earth. As they make more observations of rocks, they may discover new relationships between various rock units and, as a result, they may need to recalculate dates. Geologists are constantly looking to improve the geologic time scale and they revise it regularly.



Events in Geological History

Millions of Years Ago	Event
4500 +++	Planet formed. **Hadean eon** begins.
4000	By now, earth has a relatively stable crust with oceans and primitive atmosphere.
3800	Age of some of oldest rocks on earth's surface today. Hadean eon ends; **Archean eon** begins.
3400	Primitive, single-cell life appears.
2500	Archean eon ends; **Proterozoic eon** begins. Algae have evolved – photosynthesis begins.
1800	Oldest known rock in North Carolina.
1100	An old supercontinent collides with another, causing a mountain-building event called the Grenville orogeny. Pre-existing older rocks are metamorphosed. These are the " basement" rocks of the Blue Ridge.
800	The old supercontinent begins to pull apart; ancient ocean basin forms. Sediments (weathered pieces of " basement" rocks) accumulate and will eventually become the rocks of the Alligator Back Formation.
544	Proterozoic eon ends; **Phanerozoic eon** begins. **Cambrian period** begins – First animals with shells appear in oceans, e.g., trilobites.
505	**Ordovician period** begins – The continents of North America and Africa begin moving towards each other. Volcanic island chain collides with North American plate. Sedimentary rocks of Alligator Back Formation are folded and metamorphosed. This event is called the Taconic orogeny.
440	**Silurian period** begins – Uplift continues, along with some erosion.
410	**Devonian period** begins – Plants are thriving on land above the sea; first land animals appear; insects are common. Another mountain-building event called the Acadian orogeny occurs.
390	Magma deep within the crust rises, cools and crystallizes to form plutons, such as the one exposed at Stone Mountain today.
360	**Mississippian period** – Time of uplift and erosion.
325	**Pennsylvanian period** – Time of uplift and erosion.
300	Reptiles appear.
286	**Permian period** begins – Final collision of North America and Africa. Large masses of rock are pushed westward and piled up to form the Appalachians. The event is called Alleghanian orogeny.

Millions of Years Ago	Event
248	**Triassic period** begins – Supercontinent called Pangea begins to pull apart. Weathering and erosion of Piedmont and mountains.
225	Faulting and rifting creates Atlantic Ocean and the Triassic basins.
213	**Jurassic period** begins – Dinosaurs rule! First mammals appear.
200	Erosion continues – Overlying rocks are removed, gradually exposing the Stone Mountain pluton.
145	**Cretaceous period** begins.
78	Modern fish appear.
70	Dinosaurs become extinct; Rocky Mountains pushed up. Weathering and erosion continue in the Piedmont and mountains of North Carolina.
65	**Tertiary period** begins with **Paleocene epoch** – Limestone deposited in Coastal Plain; weathering and erosion continue in Piedmont and mountains.
60	Beginning of the Age of Mammals; first hoofed mammals and primates appear.
55.5	**Eocene epoch** begins.
33.7	**Oligocene epoch** begins.
23.8	**Miocene epoch** begins – Phosphate is deposited in eastern North Carolina.
5.3	**Pliocene epoch** begins – Erosion of Piedmont and Appalachian Mountains to their present rugged features.
1.8	**Quaternary period** begins with the **Pleistocene epoch**.
1	Time of Ice Ages.

Thousands of Years Ago	Event
100	Neanderthal man walks the earth.
40	Modern humans (*Homo sapiens*) appear.
30	People first cross over to North America.
20	Physical evolution of humans as we know them today is complete.
15	Ice sheets still cover much of North America, but *not* North Carolina.
10	Groups of people in North America begin to settle down in villages.
8	**Holocene epoch** begins – glaciers retreat.
0	Present time.

Geologic Time Information Courtesy of the North Carolina Geological Survey

Abbreviated Events in Geological History

Most geologists think that the earth is about 4.5 billion years old. Let's squeeze this vast amount of time into one day, a 24-hour cycle. On this scale, one second represents 52,000 years! Here are some benchmarks in this special 24-hour day. Notice that most of the events occurred just a few hours before midnight!

Compressed Time	Event	Approximate Real Time
12:00 Midnight	Planet Earth is born.	4.5 billion years ago
6:30 AM	Earliest life forms appear (bacteria).	3.3 billion years ago
10:00 AM	Blue-green algae appear & photosynthesis begins.	2.6 billion years ago
2:30 PM	Oldest known rock in North Carolina forms.	1.8 billion years ago
7:45 PM	Layers of sediment accumulate in an ancient ocean. This is the origin of the rocks of the Alligator Back Formation.	800 million years ago
8:15 PM	Soft-bodied sea creatures appear.	700 million years ago
9:00 PM	Hard-shelled sea creatures appear.	550 million years ago
9:15 PM	North America and Africa begin moving towards each other; sedimentary rocks in Alligator Back Formation metamorphose.	500 million years ago
10:00 PM	First land plants and animals appear; amphibians follow soon after; granodiorite pluton (now Stone Mountain) forms.	400 million years ago
10:25 PM	Early reptiles and flying insects appear.	300 million years ago
10:40 PM	Dinosaurs appear. Supercontinent known as Pangea begins to pull apart.	250 million years ago
10:50 PM	Atlantic Ocean forms; erosion removes rocks overlying Stone Mountain pluton; small mammals appear.	220 million years ago
11:00 PM	Birds appear.	195 million years ago
11:40 PM	Early primates appear; dinosaurs become extinct. Erosion continues.	65 million years ago
11:59 PM	Humans arrive seconds before midnight.	1 million years ago or less

Pre-Visit Activity #3 Mineral Study

Major Concepts:
- Composition of minerals
- Crystal shape
- Properties and uses of minerals

Learning Skills:
- Observing, classifying, inferring
- Noting important details and drawing conclusions
- Reading charts, tables and maps

Subject Areas:
- Science
- English Language Arts
- Social Studies

* See Activity Summary for a Correlation with DPI objectives in these subject areas.

Location: Classroom

Group Size: 30 or less

Estimated Time: 45 minutes; more time if do additional activities

Appropriate Season: Any

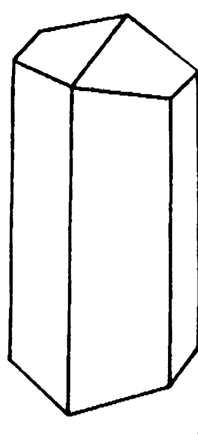
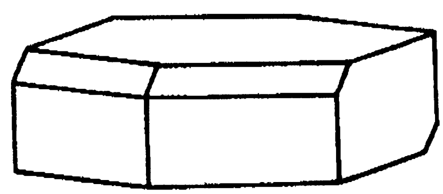
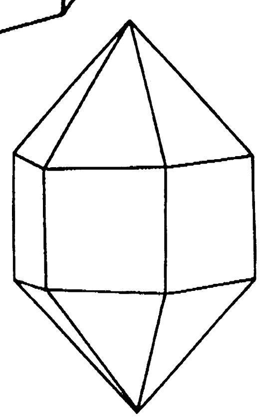
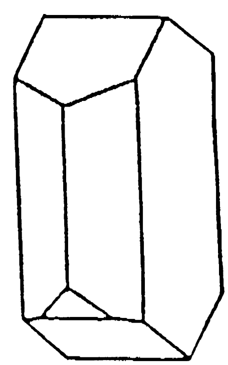
Materials:
Provided by the educator:
Per student: Student's Information; Optional - mineral crystal cutout page(s); Periodic Table
Per class: Specimens of quartz, feldspar, biotite and hornblende (crystals if possible); Optional – specimens of rocks with visible mineral crystals and magnifying glasses.
Per class: Large box containing some of the following items – quartz watch, amethyst ring or necklace, pressure gauge, camera, eyeglasses, sandpaper, polishing compound (car wax), computer chip (or picture of computer), calculator, sand, fertilizer, drinking glass, ceramic dish, soap, abrasive cleanser or scouring powder, roofing shingle, piece of fabric, sheet of paper, paint can, Christmas-tree "snow," plastic bottle, rubber band, lipstick, cold cream, and vitamins.

Credits: Adapted from the "Uses of Minerals and Rocks Mined In North Carolina" and "Your House Comes From a Mine!" activities found in the North Carolina Geological Survey's *Mineral and Rock Kit Guide*. Facts and statistics in Student's Information were provided by NCGS.

Objectives:
- Name three minerals found in the granodiorite rock at Stone Mountain.
- Describe the chemical composition and crystal shape of feldspar, quartz and biotite.
- List at least two uses for feldspar, quartz and biotite.

Educator's Information:

In this activity, the students will study **minerals** usually found in **granodiorite rock.** (The rock that makes up Stone Mountain is classified as granodiorite.) The students will read about the chemical composition, crystal structure and uses of each mineral. Optional activities are suggested to give the students additional experiences with these minerals.

Instructions:

1. Place pieces of **quartz**, **feldspar** and **biotite** in three different locations in the classroom. Note: Samples of these minerals can be found in the Rock and Mineral Kit from NC Geological Survey. If possible, try to include specimens or photographs that show the crystal shape of each mineral. Place the other items listed in the Materials section in a large box in the front of the room. Photocopy the Student's Information for each student.

2. Ask students to read the Student's Information, carefully underlining or noting important ideas. Then have students come, one at a time, to take an item from the box and physically place it next to the main mineral used to create it. Students should do this quickly without talking to others.

3. When all the items are placed, ask if everyone agrees with the placement. Move items to another mineral's location if good arguments can be made for doing so. Note that some items are made from more than one mineral – there could be more than one correct answer. Use the Student's Information to check for accuracy and to discuss how each of the minerals is used to produce specific items.

Optional Activities:

1. Younger students might enjoy creating mobiles of mineral crystals from the Two Dimensional Cutouts page provided in this activity. Or students can create three-dimensional models of a quartz or feldspar crystal using the Three-Dimensional Cutout page in this activity.

2. Provide samples of **granite** or granodiorite and/or other rocks that contain visible mineral crystals or grains. Ask students to observe the rocks using a magnifying glass or dissecting microscope and draw what they see. Note that granite and granodiorite are similar. However, granodiorite contains *less* potassium feldspar (orthoclase) and *more* of the sodium-rich plagioclase feldspar. Granodiorite also usually contains more dark-colored minerals such as biotite and **hornblende**. The granodiorite at Stone Mountain is composed mostly of feldspar, quartz and biotite. Hornblende, if present, is difficult to see.

3. Ask students to use the periodic table provided in this activity to list all the **elements** found in biotite, the feldspar group, and hornblende. Then, have the students find chemical formulas for other minerals in reference books or field guides. Again, list the elements in each mineral. What uses can students find for each mineral?

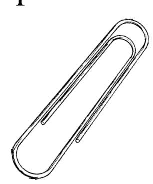
4. Have students locate Spruce Pine, North Carolina, on a state map. Older students can refer to the " Generalized Geologic Map of North Carolina" from NC Geological Survey for a small state map showing locations of principal mineral-producing areas. Using reference guides and a map of North America, find other locations where quartz, feldspar and biotite are mined.

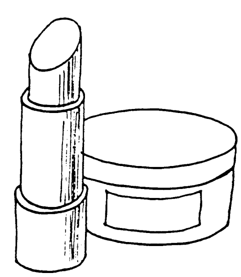
Assessment:

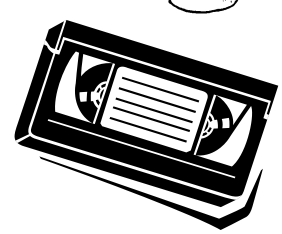
Use the test provided at the end of this activity, or create one of your own.

Extension:

If you have extra samples of minerals, students can perform **hardness** tests on them, or study **fracture/ cleavage**. Allow students to devise their own classification schemes for the mineral specimens you provide.







Student's Information:

Life has always depended on **minerals**. Today, plants, animals and people get their essential **nutrients** from minerals and their building blocks, the **elements**.

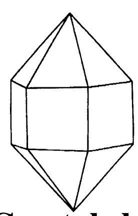
A mineral is a naturally-formed, **inorganic** substance with specific physical properties. Each mineral has a definite chemical composition and a distinctive **crystal** shape. For example, the mineral **quartz** always has a chemical formula of SiO_2, silicon dioxide. This means that quartz is made up of two elements: Si for silicon and O for oxygen.

The chemical formula or composition of a mineral helps to determine the shape of its crystals. Quartz crystals are hexagonal, or six-sided. Quartz specimens found all over the world have these same characteristics. No mineral except quartz has this same set of characteristics.

The **igneous rock** found at Stone Mountain State Park is called **granodiorite**. In this activity, you will focus on four minerals found in most granodiorite rocks. The four minerals are quartz, **feldspar**, **biotite** and **hornblende**. Because the **magma** that formed this rock cooled slowly inside the earth's crust, the mineral grains are large enough to be easily seen.

The minerals easily seen in Stone Mountain granodiorite are quartz, feldspar and biotite. The quartz looks like pieces of clear to gray glass; feldspar is dull white; and, biotite looks like shiny black flakes. If present, hornblende appears as glassy, black needles.

These four minerals are called **silicate** minerals because they all contain the element silicon. Since they contain some of the same elements, they have some similar properties and uses. But, they also have unique properties and uses all their own!



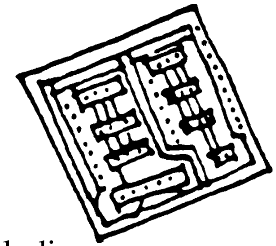
QUARTZ

Chemical formula: SiO_2

Crystal shape: Six-sided prisms that end in pyramidal points.

Physical Properties and Uses:

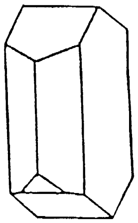
Quartz displays **piezoelectricity** – pressure on a quartz crystal causes electrical charges to be produced across the crystal. An electrical charge placed on the crystal will cause it to vibrate. This property makes quartz the main component in watches, computer chips, transistors for radios and calculators, solar cells, and other precision instruments



including pressure gauges, **oscillators**, **resonators** and **wave stabilizers**.

Because of its transparency and ability to affect the transmission of light rays, quartz is used to make the glass in many optical instruments. Examples are camera lenses, telescope mirrors, eyeglasses and heat-ray lamps. High-quality, North Carolina quartz was used to make the mirror in the famous telescope at the Mt. Palomar Observatory in California.

Quartz is a semiprecious stone. Amethyst jewelry is made from purple quartz. Many other fine gem specimens of quartz found in North Carolina include citrine or yellow quartz, smoky or gray quartz, rutilated quartz (needlelike crystals of **rutile** are imbedded in the quartz), and adventurine or green quartz. Ground-up quartz is used in industry to create ceramics, hydraulic cements, water filtration units, sandpaper, polishing compounds and scouring powder. It is also used as a filler in cosmetics (lipstick and cold cream), pharmaceuticals (vitamins and minerals), and rubber (rubber bands).



FELDSPAR

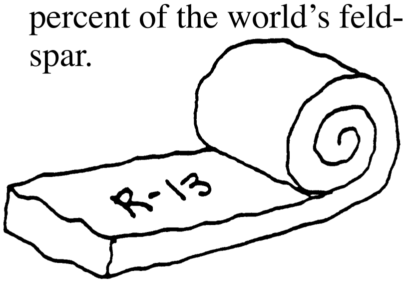
The name "feldspar" actually refers to a group of minerals.

Chemical formula: varies depending on the type of feldspar, and there can be more than one type in the same rock. For plagioclase feldspars, formulas range from $NaAlSi_3O_8$ to $CaAl_2Si_2O_3$, and for orthoclase (potassium feldspar) the formula is $KAlSi_3O_8$.

Crystal shape: prism-shaped, rectangular

Physical properties and uses:

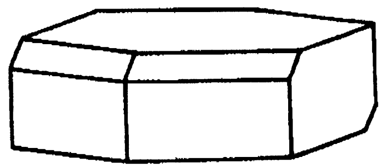
Feldspar is mined from **pegmatite** and other **intrusive igneous rocks** at Spruce Pine, North Carolina, in Mitchell County. North Carolina provides about 70 percent of the world's feldspar.



Feldspar is an important industrial mineral used in many products: glass and ceramics, pottery and enamel ware, soaps, abrasive cleaners, bond for abrasive wheels, cements and concretes, insulation, fertilizer, poultry grit, roofing materials (shingles), and filler in textiles and papers. Fiberglass insulation is made from fused quartz and feldspar.

Many of the more than 70 varieties of feldspar can be cut into gems or rounded into beads. Varieties found in North Carolina are moonstone with a pearly luster, amazonite (blue-green feldspar), and sunstone which displays flashes of color.

BIOTITE

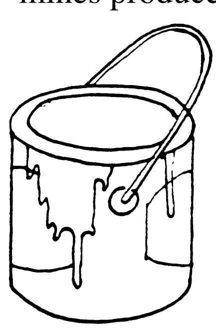


Chemical formula: $K(Mg,Fe)_3Si_3O_{10}(OH)_2$

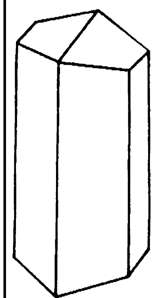
Crystal shape: tabular with six sides

Physical properties and uses:

Large, thin translucent sheets of biotite (the dark-colored form of mica) were once used to make heat-resistant windows in ovens, toasters and furnaces. In our state, muscovite (the light-colored form of mica) is mined from pegmatites and alaskite in Avery, Mitchell and Cleveland counties. North Carolina mines produce about 65,000 metric tons of scrap mica (ground-up mica) per year valued at over $3.5 million.



Mica is used in many products including paints, plastics, plasterboard, wallboard joint cement, well-drilling muds, roofing, welding rods, rubber, cosmetics (lipstick and cold cream) and cement.



HORNBLENDE

Chemical formula: $Ca_2Na(Mg,Fe_2)_4(Al,Fe_3,Ti)(Al,Si)_8O_{22}(O,OH)_2$

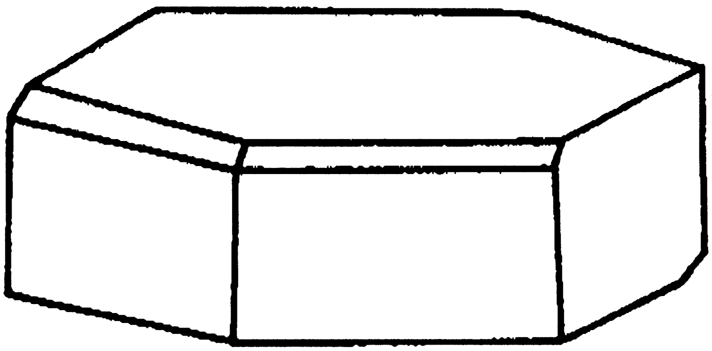
Crystal shape: prismatic

Physical properties and uses:

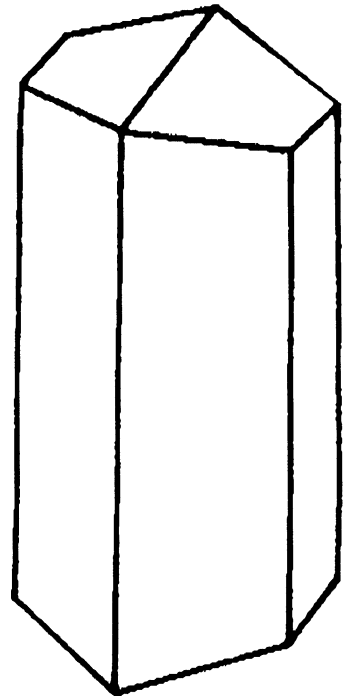
Hornblende belongs to a group of minerals called the **amphiboles**. Although hornblende has no real commercial value at this time, it is rich in iron. In the future, rocks with large amounts of hornblende might be used as a source of iron. Think about all the ways we use iron in our daily lives. Iron is used in making steel for cars, appliances, buildings, cans, tools, farm and factory machinery, pipes, shovels, and more.

Hornblende is a major component of **amphibolite**, which is one of the common metamorphic rocks of the **Alligator Back Formation** surrounding Stone Mountain State Park. Pieces of amphibolite are also found as **xenoliths** in the granodiorite of Stone Mountain.

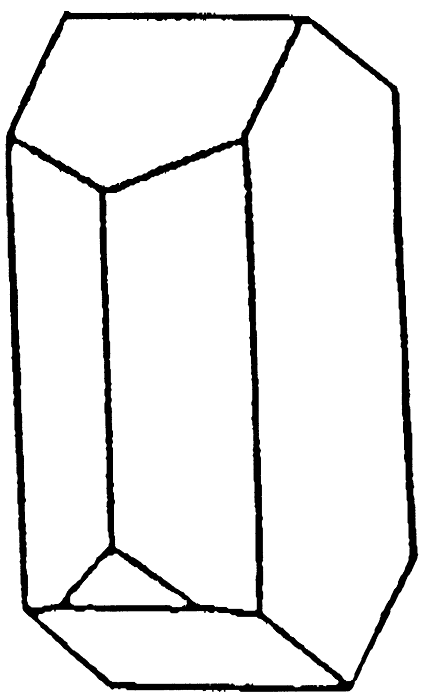
Two-Dimensional Cutouts



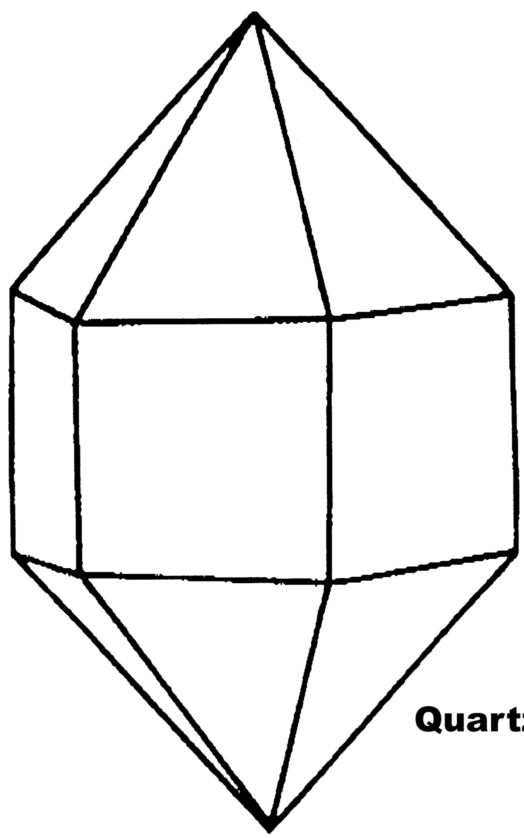
Biotite



Hornblende

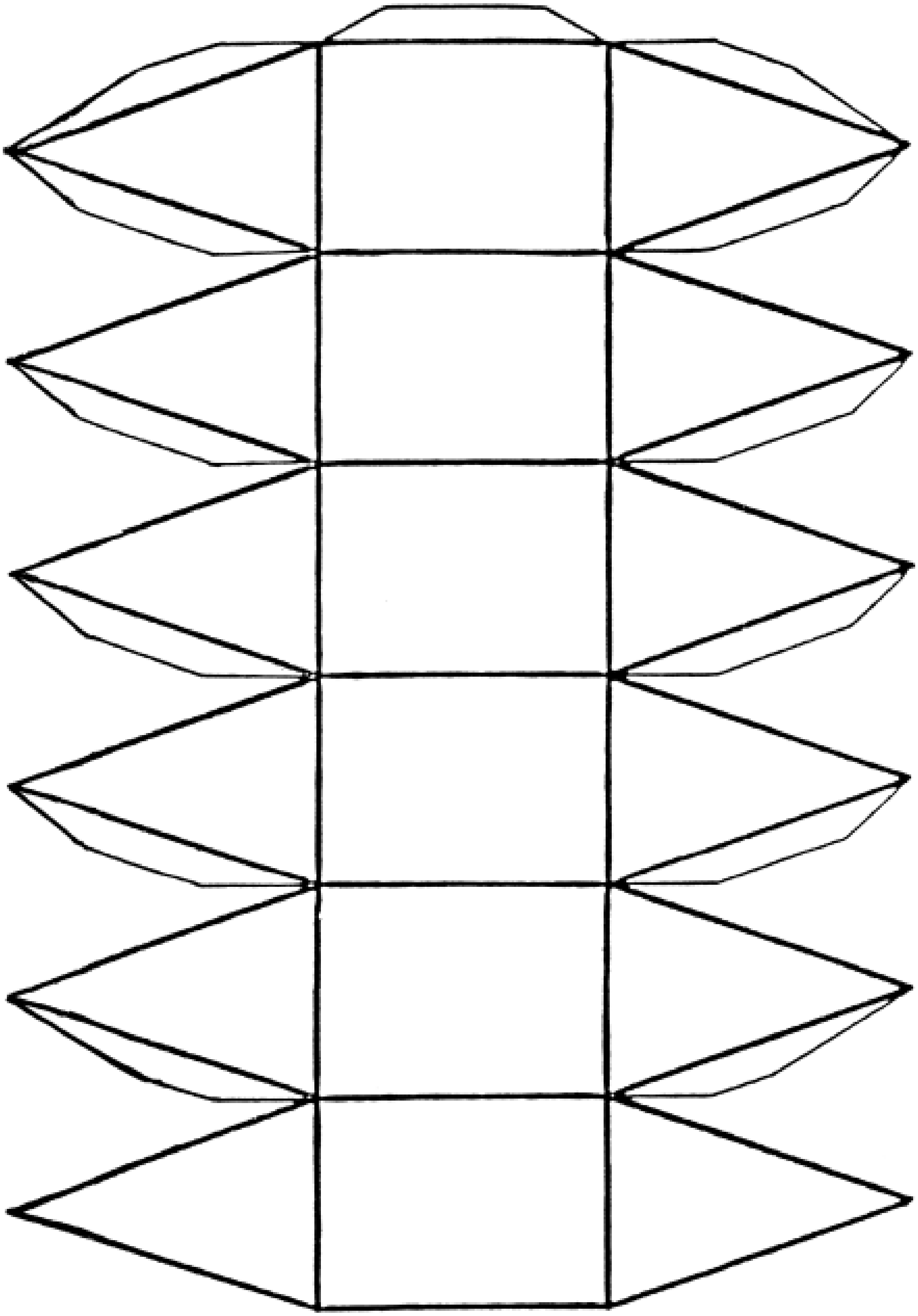


Feldspar

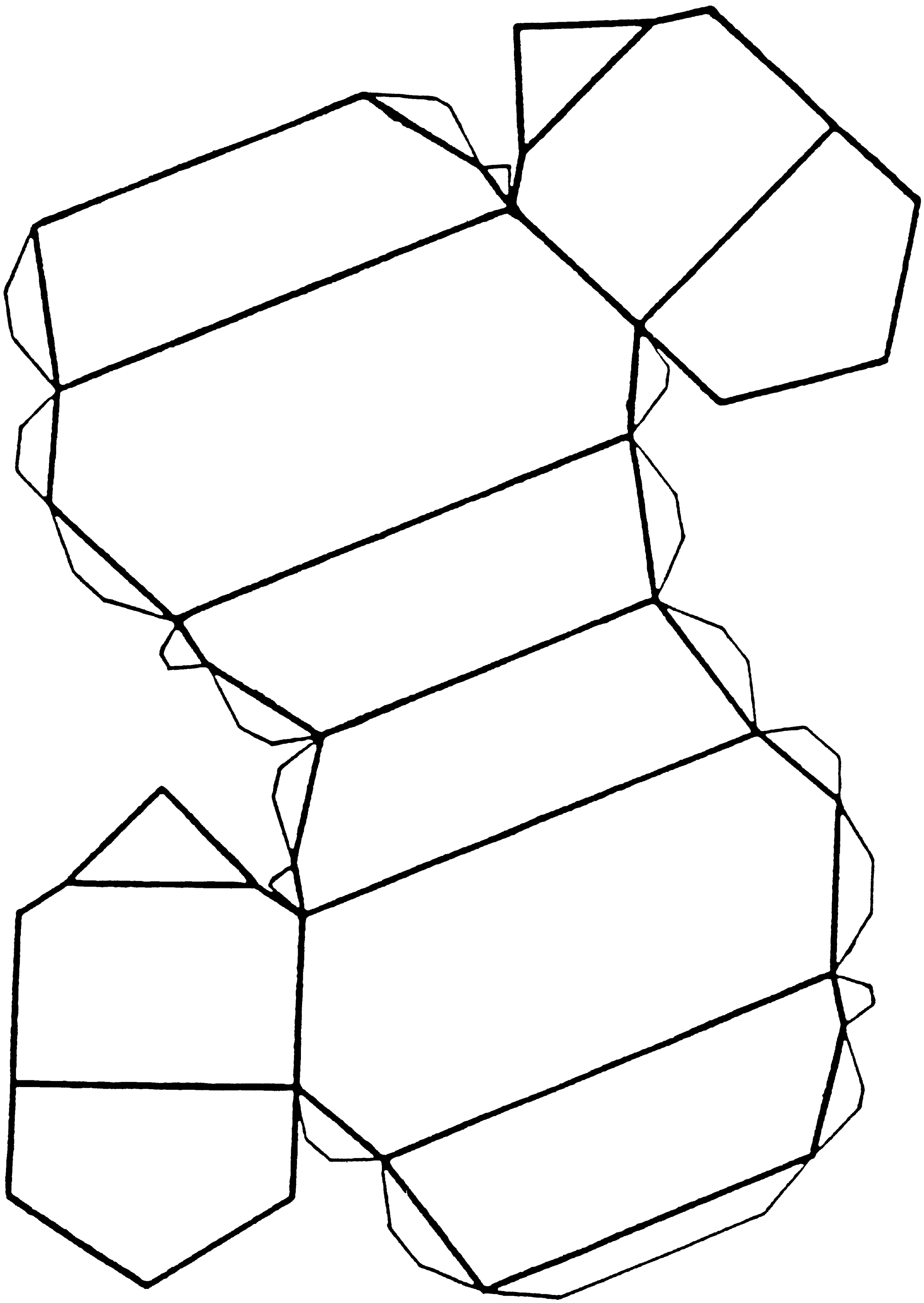


Quartz

Three-Dimensional Cutouts



Quartz Crystal



Feldspar Crystal

Periodic Table of Elements

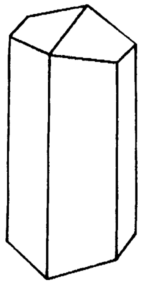
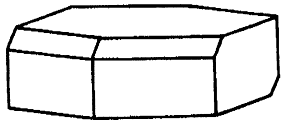
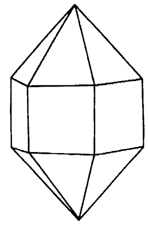
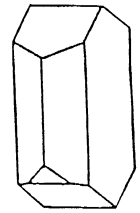
Transition Elements (B Groups)

Period	Group I	II	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	III	IV	V	VI	VII	O
1	1 H Hydrogen																	2 He Helium
2	3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
3	11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
4	19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Callium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
5	37 Rb Rubdium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
6	55 Cs Cesium	56 Ba Barium	57-71 See below	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
7	87 Fr Francium	88 Ra Radium	89-103 See below															

57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lw Lawrencium

Mineral Study - Test

Name: ____

1. _____ 2. _____ 3. _____ 4. _____

Match the crystal shape with the mineral:

B = Biotite F = Feldspar H = Hornblende Q = Quartz

Match the chemical formula with the mineral:

1. _____ $Ca_2Na(Mg,Fe_2)_4\ (Al,Fe_3,Ti)\ (Al,Si)_8O_{22}\ (O,OH)_2$

2. _____ SiO_2

3. _____ $NaAlSi_3O_8$

4. _____ $K(Mg,Fe)_3Si_3O_{10}(OH)_2$

Match the uses with the correct mineral:

1. _____ Plastics, paints and cosmetics

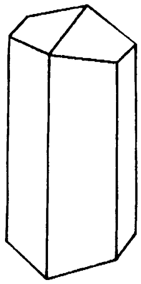
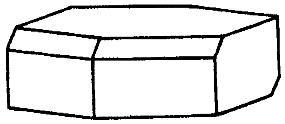
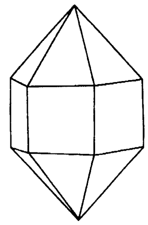
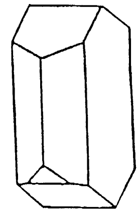
2. _____ Source of iron

3. _____ Watches, computer chips, telescopes

4. _____ Fertilizer, poultry grit, ceramics

Mineral Study - Test - ANSWERS

Name: ____

1. H **2. B** **3. Q** **4. F**

Match the crystal shape with the mineral:

B = Biotite F = Feldspar H = Hornblende Q = Quartz

Match the chemical formula with the mineral:

1. H $Ca_2Na(Mg,Fe_2)_4\ (Al,Fe_3,Ti)\ (Al,Si)_8O_{22}\ (O,OH)_2$

2. Q SiO_2

3. F $NaAlSi_3O_8$

4. B $K(Mg,Fe)_3Si_3O_{10}(OH)_2$

Match the uses with the correct mineral:

1. B **Plastics, paints and cosmetics**

2. H **Source of iron**

3. Q **Watches, computer chips, telescopes**

4. F **Fertilizer, poultry grit, ceramics**

On-Site Activity #1 — Igneous Intruder

Major Concepts:
Part I
- Intrusive igneous rock
- Erosion
- Landforms – pluton and exfoliation dome

Part II
- Weathering and erosion
- Land use
- Succession

Learning Skills:
- Observing, communicating, inferring, making models
- Writing descriptive and expository text

Subject Areas:
- Science
- English Language Arts
- Social Studies

* See Activity Summary for a Correlation with DPI objectives in these subject areas.

Location:
Stone Mountain State Park

Group Size: 30 or less

Estimated Time:
Part I: 1 hour
Part II: 1 and 1/2 hours

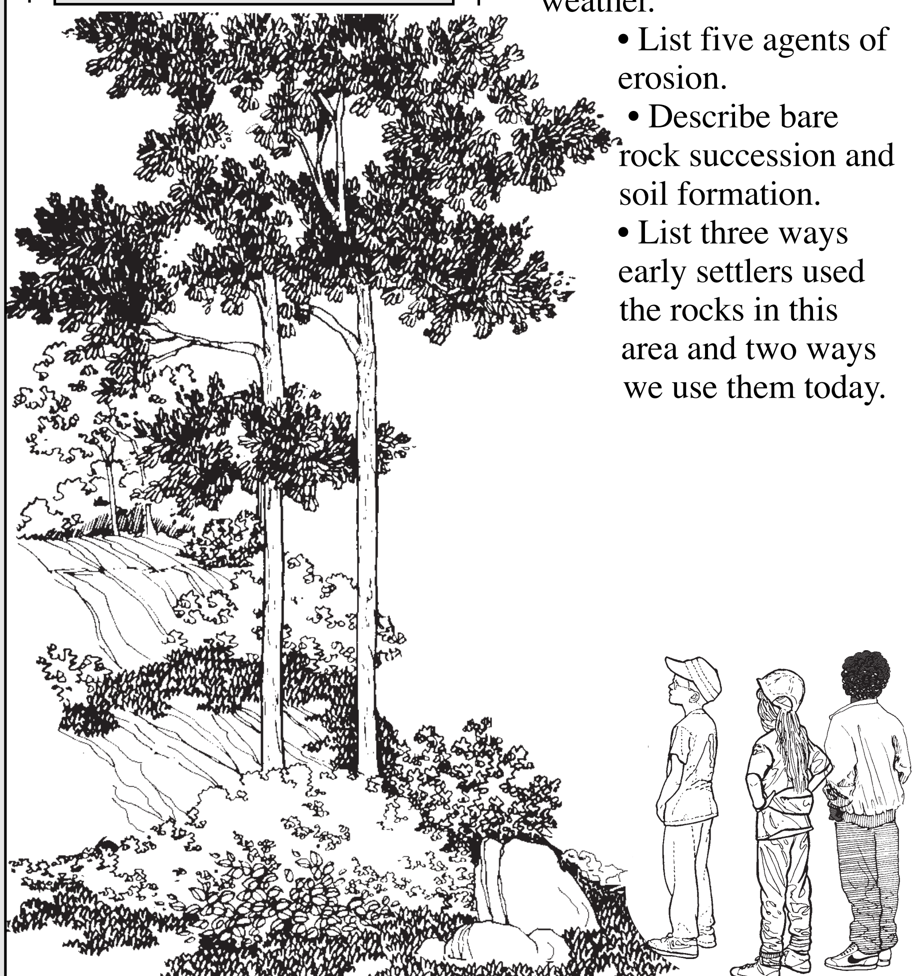
Appropriate Season: Any

Materials:
Part I:
Provided by the educator:
Per student: pencils, paper, crayons, drawing markers, clipboard, Igneous Intruder Worksheet, Student's Information
Provided by the park: plywood box, air hose, inflatable rubber ball, inflation needle, bicycle pump, buckets of soil and small rocks, watering can, water, samples of granodiorite, hand lenses
Part II:
Provided by the park: 15 hand lenses

Special Considerations:
Part II of this on-site activity will require hiking, which could expose the students to hot, humid conditions as well as ticks, bees and snakes. Accessibility to some of these areas may be difficult for persons with special needs. Leaders should make students aware of hazards associated with rocks, high places and water.

Objectives:
Part I:
- Describe and illustrate how Stone Mountain was formed.
- List three minerals found in the granodiorite of Stone Mountain.
- Demonstrate awareness of the importance of plutons or exfoliation domes to human society.

Part II:
- Describe five factors that can cause rocks to weather.
- List five agents of erosion.
- Describe bare rock succession and soil formation.
- List three ways early settlers used the rocks in this area and two ways we use them today.



Part I: Igneous Intruder

Educator's Information:

During this activity, the class will participate in a demonstration that illustrates how geologists think Stone Mountain was formed. The educator should be familiar with the geologic history of Stone Mountain given on page 1.7 of this EELE.

Instructions:

1. Pass around samples of **granodiorite** and have the students identify the **minerals** with the hand lenses. The **feldspar** looks white; the **quartz** is glassy and clear to gray in color; and the **biotite (mica)** resembles shiny black flakes. (**Hornblende**, if present, looks like glassy, dark-green to black needles.) How do they think this rock could have formed? Discuss the Student's Information as appropriate.

2. Announce that this activity simulates a well-accepted geological theory explaining how Stone Mountain formed.

3. Have a few students pour the buckets of soil and **rocks** into the plywood box. The students will "build a mountain" about one foot high from these materials. (A deflated ball, covered with soil materials, will already be in the box so the students can't see it. An air hose will be connected to the ball and run to a bicycle pump outside of the box.) Have the students draw a picture of their "mountain" in box #1 of the Igneous Intruder Worksheet.

4. After completing the "mountain building," have a student use the watering can to pour a few gallons of water on top of the "mountain." Notice what happens. Soil and smaller rocks are moved from one place to another. Have the students draw a picture of how the mountain now looks in box #2 on their worksheet.

Talk about the geologic forces that break up and move rocks. Emphasize that millions of years ago, the Appalachian Mountains were much taller than they are today, but **weathering** and **erosion** have removed miles of material from them.

5. Discuss what an **intrusive igneous rock** is, then have a student pump the bicycle pump. The rubber ball buried beneath the "mountain" will start rising. Pumping air into the ball represents **magma** intruding into the overlying bedrock. As the "magma" continues to intrude, the "mountain" will start to move. The soil on the "mountain" will crack and materials will be carried down the "mountain." Have the students draw a picture of how the "mountain" now appears in box #3 of their worksheets.

When resistance is felt against the bicycle pump, have the student stop pumping. At this point the hidden ball should be mostly inflated.

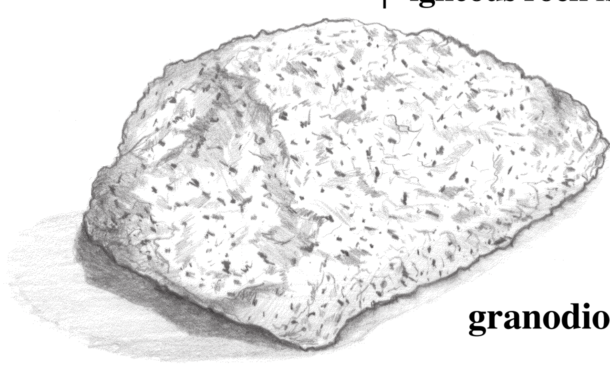
6. Have a student pour enough water on the "mountain" to expose the "face of Stone Mountain" (the ball). Have the students draw the final appearance of "Stone Mountain" in box #4 of their worksheets.

7. Make sure that your students have a chance to view the actual exfoliation dome of Stone Mountain. Discuss: does the real mountain look anything like the model in the demonstration?

8. Have the students find a place by themselves where they can sit down and complete the worksheet.

Assessment:

Use the test provided for Part I of this activity, or create your own.



granodiorite

Student's Information - Part I

Imagine going back in time about 250 million years. The Appalachian Mountains were one to three miles higher than they are today. (They were about as tall as the modern Alps or Rocky Mountains.) Now imagine the **rocks** forming Stone Mountain buried beneath much of this mountain material. How did these rocks get to the surface of the earth and take on the domelike shape we see today?

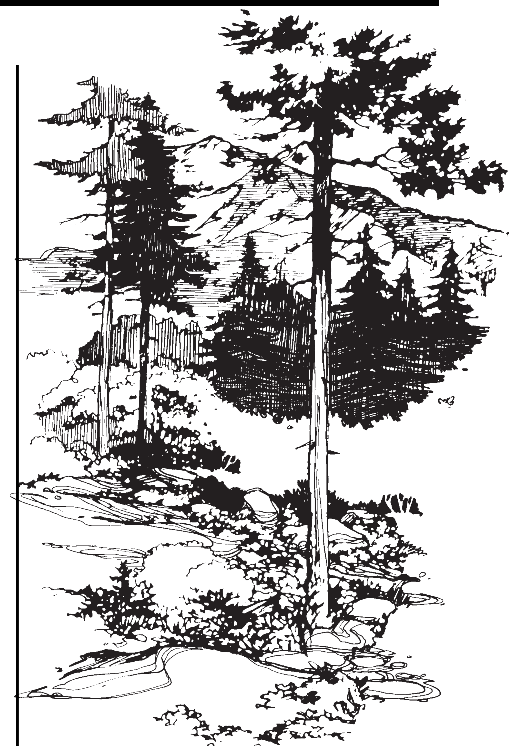
Geologists have a theory. Beginning with careful observations of the rock formations, geologists have constructed a sequence of events to explain how Stone Mountain formed. The story begins with the birth of the Appalachian Mountains about 470 million years ago. Mountain building is related to the movement of the **tectonic plates** that make up the earth's crust. About 470 million years ago, the plates carrying the continents of Africa and North America started moving towards each other.

In association with the plate movements, pockets or pods of **magma** formed deep in the earth's crust about 390 million years ago. One of these pods formed below the rock units that now make up Alleghany and Wilkes counties. As the magma rose toward the surface, it "ate" through and incorporated some of the older rock formations it was moving through. The magma cooled and crystallized well below the earth's surface. It created a body of **intrusive igneous rock** known as a **pluton**.

The mountain-building process continued. The Appalachians reached their greatest heights as Africa collided with North America around 250 million years ago. Shortly after this, North America and Africa began to drift apart. **Weathering** and **erosion** became the dominant **geological processes** in North Carolina. It took millions of years for weathering and erosion to remove the miles of earth and rock lying on top of the pluton. But, finally, the pluton was exposed at the earth's surface.

As the overlying rock was removed, the release in surface pressure caused the plutonic rock to expand slightly upward and outward. Joints and cracks formed parallel to the rock's surface. Thin, curved sheets of weathered rock fell away. Through continued weathering and erosion, the mountain took on a curved, domelike shape. This type of weathering process is called **exfoliation** and the resulting landform is known as an **exfoliation dome**. The same geological processes continue at Stone Mountain today.

Exfoliation domes are remarkable landforms that impress everyone with their scenic beauty. They provide many recreational opportunities such as hiking, bird watching and rock climbing.



The **granodiorite** that makes up the Stone Mountain pluton is a very hard, light-colored, coarse-grained rock. It is composed primarily of **feldspar** (60%) and **quartz** (30%) with lesser amounts of **biotite** and, possibly, other dark-colored minerals such as **hornblende**. The dull white areas are feldspar; the glassy, clear to gray areas are quartz; and the black flakes are biotite (mica). Hornblende, if present, looks like black to dark-green, glassy needles.

The granodiorite pluton at Stone Mountain is similar to the one that is mined at Mt. Airy, North Carolina. Mt. Airy "granite" is a beautiful stone used worldwide in the construction of buildings and monuments.

Igneous Intruder Worksheet

Draw a series of pictures illustrating how Stone Mountain formed.

Box #1	Box #2
Box #3	Box #4

Describe how geologists think the pluton and exfoliation dome of Stone Mountain might have formed.

List and describe three minerals you can easily see in the granodiorite of Stone Mountain.

Explain the importance of state parks and other protected lands in preserving areas of significant natural beauty.

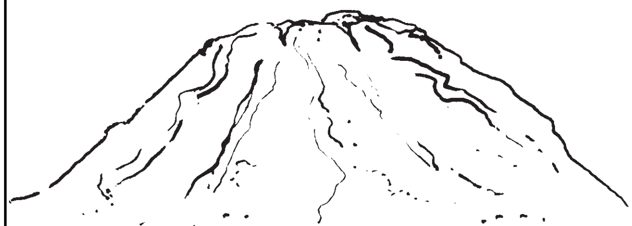
On the back of this paper, create your own theory to explain how Stone Mountain might have formed. What evidence would you look for in the park to support your ideas?

Igneous Intruder Answer Sheet

Draw a series of pictures illustrating how Stone Mountain formed.

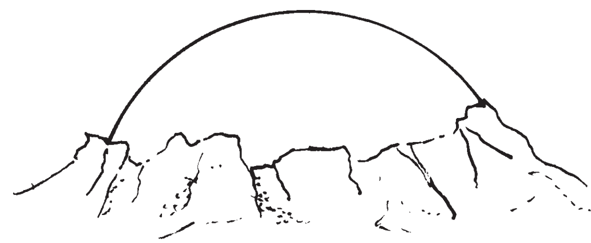
Box #1

Box #2



Box #3

Box #4



Describe how geologists think the pluton and exfoliation dome of Stone Mountain might have formed.

A pocket of magma formed several miles deep in the earth. The magma rose upward and cooled slowly beneath the earth's surface, creating a pluton of intrusive igneous rock called granodiorite. Later, forces of weathering and erosion stripped away the overlying rocks. As the miles of earth and rock overlying the pluton were removed, the release in surface pressure caused the rock mass to expand upward and outward. As it expanded, cracks formed parallel to the surface and large slabs, or exfoliation sheets, fell off. These curved exfoliation sheets help to define the mountain's dome shape.

List and describe three minerals you can easily see in the granodiorite of Stone Mountain.

(1) feldspar - dull white; (2) quartz - glassy, clear to gray; (3) biotite - shiny black flakes

Explain the importance of state parks and other protected lands in preserving areas of significant natural beauty.

(Sample Answer; student responses may vary.) With an ever-growing human population, state parks are needed to preserve and protect scenic wild lands. Through our state parks, future generations will have many of the same opportunities to enjoy nature and explore rock formations as we do today.

On the back of this paper, create your own theory to explain how Stone Mountain might have formed. What evidence would you look for in the park to support your ideas?

Accept any answer as long as the student suggests evidence to support ideas. This question could lead to other investigations or, at least, give the instructor more information about the student's thought processes.

Part I: Test for Igneous Intruder

Name: ____

List and describe three minerals found in granodiorite rock at Stone Mountain State Park. Be sure to list the minerals in order from most abundant to least abundant in the granodiorite.

1. ____
2. ____
3. ____

How did the landform known as Stone Mountain form?

Geologists have developed a theory to explain how Stone Mountain formed. Below you will find events in the geological history of Stone Mountain. Number these six events in order from the oldest event to youngest event. The event that you call #1 should have occurred first (oldest) and #6 should have occurred last (most recent).

_____ Millions of years of erosion remove much of the rock lying on top of the granodiorite **pluton**. The pluton is exposed at the earth's surface.

_____ The pod of **magma** begins to rise upwards, pushing through the older, overlying rock.

_____ Large, curved sheets of weathered rock form and are eroded away, creating a dome-shaped mountain, called an **exfoliation dome**.

_____ Rocks begin to melt deep in the earth's crust as a result of mountain-building activity. A pod of **magma** forms.

_____ **Joints and cracks** form parallel to the surface of the rock as it weathers. The rock expands slightly upwards and outwards.

_____ The **magma** cools slowly. Finally, the magma solidifies to form a **pluton** of granodiorite rock, located several miles below the earth's surface.

On the back of this paper, explain why you agree or disagree with the following:

Unusual landforms, such as the exfoliation dome of Stone Mountain, should be protected and preserved for future generations.

Note: There are no right or wrong answers. You will be graded only on your writing.

Part I: Test Answers

Name: ______________________________

List and describe three minerals found in granodiorite rock at Stone Mountain State Park. Be sure to list the minerals in order from most abundant to least abundant in the granodiorite.

1. *Feldspar - looks dull white*
2. *Quartz - looks glassy, clear to gray*
3. *Biotite - looks like shiny black flakes*

How did the landform known as Stone Mountain form?

Geologists have developed a theory to explain how Stone Mountain formed. Below you will find events in the geological history of Stone Mountain. Number these six events in order from the oldest event to youngest event. The event that you call #1 should have occurred first (oldest) and #6 should have occurred last (most recently).

4	Millions of years of erosion remove much of the rock lying on top of the granodiorite pluton. The pluton is exposed at the earth's surface.
2	The pod of magma rises upwards, pushing through the older, overlying rock.
6	Large, curved sheets of weathered rock form and are eroded away, creating a dome-shaped mountain, called an exfoliation dome.
1	Rocks begin to melt deep in the earth's crust as a result of mountain-building activity. A pod of magma forms.
5	Joints and cracks form parallel to the surface of the rock as it weathers. The rock expands slightly upwards and outwards.
3	The magma cools slowly. Finally, the magma solidifies to form a pluton of granodiorite rock, located several miles below the earth's surface.

On the back of this paper, explain why you agree or disagree with the following:

Unusual landforms, such as the exfoliation dome of Stone Mountain, should be protected and preserved for future generations.

Note: There are no right or wrong answers. You will be graded only on your writing.

Teachers should provide a rubric for this test item.

Part II: Rock Walk

Educator's Information:

The class will take a short hike on the self-guided nature trail at the base of Stone Mountain to see evidence of **weathering**, **erosion**, **deposition** and succession. The group will walk a trail over **rocks**, roots and water, so caution is needed to prevent injury.

Instructions:

1. Discuss basic trail safety information with the students. (See Special Considerations on page 4.1.1.) Remind the students that the purpose of the state parks system is to preserve and protect our natural resources. They should not pick, injure or destroy any plants or animals. Rocks should not be removed from the park.

2. Discuss the Student's Information with the class before arriving at the park. For each stop, have one of the students read aloud that stop's information as the rest of the class looks for and identifies the objects and processes described.

Note: If you prefer an inquiry-based aproach, allow the students to explore the area around each stop and develop their own questions. Use the material given here as background information to help you guide student discovery.

Stop 1: Field at Base of Stone Mountain

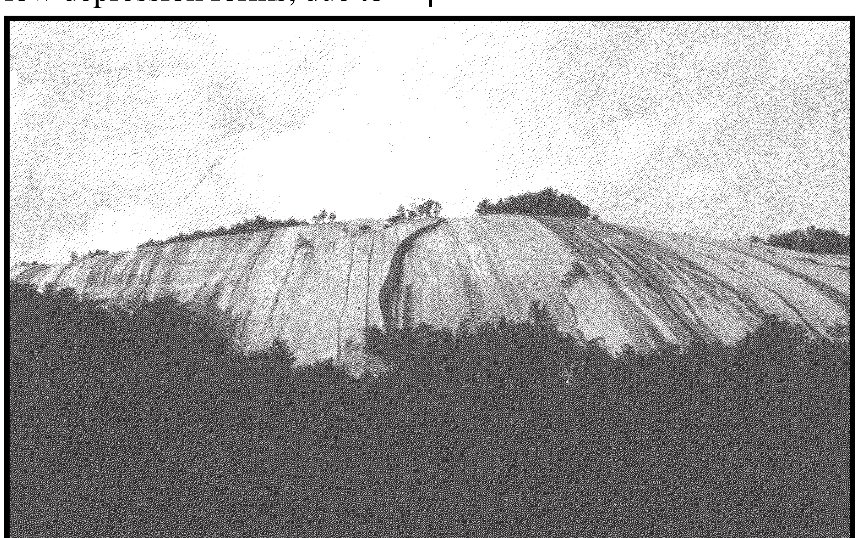
<u>Read Aloud:</u>

This field is a pasture created by early settlers. It is maintained by the park to help preserve the cultural past and provide a vista of the mountain for visitors. Look at the surface of the field. Notice the mounds and shallow ditches that were used to control the direction and force of running water to help prevent **erosion**. Deer and rabbits use the field as a food source and can often be seen grazing here.

As you look at the south-facing slope of Stone Mountain, notice the shape of the rock and the trees growing on it. Also, notice the Great Arch, which was formed when part of the mountain's rock **exfoliated**.

The trees you see growing on the mountain are part of a never ending cycle called bare rock succession. First, a shallow depression forms, due to **weathering** and erosion. Next, sand and soil are washed or blown into the weathered pit. Mosses and grasses start growing in the collected soil. They help hold moisture and add **organic** material that enriches the soil. Over time, more soil accumulates and eventually, if the soil is rich and deep enough, trees and shrubs are able to survive. As the trees get taller and more top heavy, winds will sometimes blow them over, for they are not deeply rooted. The soil mat is lifted out by the tree's roots and then is often washed away. The whole process of building up the soil in the weathered pit then starts over again.

The plants that live in these weathered depressions have to contend with desertlike conditions. The soil is often sandy and poor in nutrients, just like desert soils. Most of the time the soil is very dry because of rapid evaporation of the mois-



ture by wind and sun. The plants also have to adapt to high light intensity caused by the reflection of sunlight off the rock. The rock surface temperature in summer often exceeds 100 degrees F. These desertlike conditions place the plants under a lot of stress, causing them to grow more slowly than identical species growing in a better habitat. The trees growing on the rock are often stunted and gnarled from the harsh environment. This gives them a "bonsai" character that is both intriguing and beautiful.

Stop 2: Climbing Display Exhibit

Read Aloud:

Granodiorite boulders of various shapes and sizes are scattered everywhere. All these rocks broke off Stone Mountain and tumbled down. This mature forest growing among the boulders is very diverse, containing many different species of trees.

The dominant oak here is the chestnut oak. It commonly grows on rocky slopes, where precipitation drains away quickly, leaving the soil very dry most of the time. Almost all the larger chestnut oaks are hollow. They provide homes for many animals, including woodpeckers, nuthatches, owls, squirrels, raccoons, opossums, insects, mice and snakes.

Teacher Instructions:

While the students are looking at the Climbing Display, go over the information given there. Explain the park's rules and regulations regarding rock climbing.

Stop 3: Practice Rocks

Read Aloud:

The first rock has a slanted surface where we can practice friction climbing. Stone Mountain is famous among climbers as one of the best friction climbing mountains in the Southeast. The second practice rock has shallow indentations in the rock, called lentils, that can be used for handholds and footholds.

Next is the balanced rock. The top surface of the bottom rock has black moss growing on it. The firmly anchored moss obviously needs no soil, just the rough rock surface. It is slowly breaking down this rock with its small roots, the acid produced by its decaying leaves, and its ability to hold moisture longer after a rain than if the rock surface were bare. Notice the small rock material on top of the bottom rock at the base of the balanced rock. This sandy material comes from the balanced rock as it erodes away. It is a slow but steady process. The surface of the balanced rock is rough and bumpy due to this weathering process.

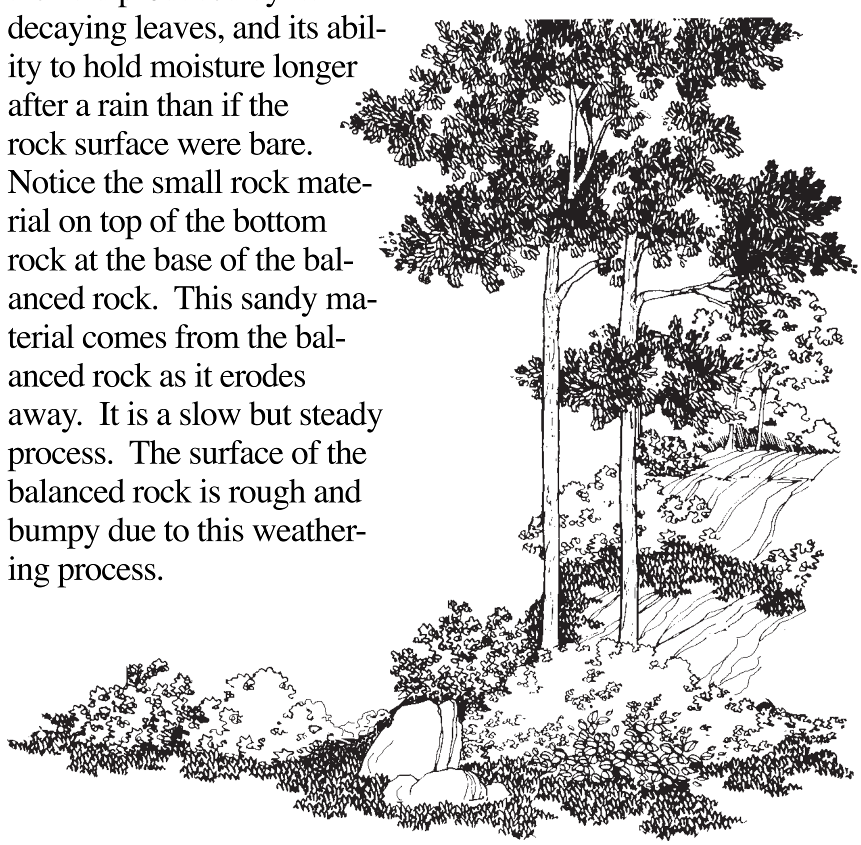
Teacher Instructions:

Have the students practice climbing these two boulders to let them experience how difficult rock climbing can be and what granodiorite rock feels like. Have several students push up on the balanced rock. They will get an appreciation of just how heavy granodiorite is, as they will not be able to move the rock at all. As the students hike to Stop 4, just off the nature trail at the base of the mountain, call their attention to the number of trees growing on top of the rocks.

Stop 4: Base of Stone Mountain

Read Aloud:

Over time, many of the rocks at the base of the mountain have become rounded by the rainwater pouring off Stone Mountain. The rounding of the stone is caused primarily by



the sandy particles carried by the rainwater flowing off Stone Mountain. The particles act like sand blasters on the rocks at the mountain's base.

Off to the right, you can see grass, called broomsedge, growing out of a crack going straight up the rock. Also notice the birch tree with most of its roots exposed on top of the rock. This shows how adaptable some plants can be.

Teacher Instructions:

Have the students lean forward and touch the rock. How does it feel? Cold or hot? Rough or smooth?

Return to the Nature Trail by the same route.

Stop 5: Threshing Rock

Teacher Instructions:

Have the students sit on the "threshing" rock.

Read Aloud:

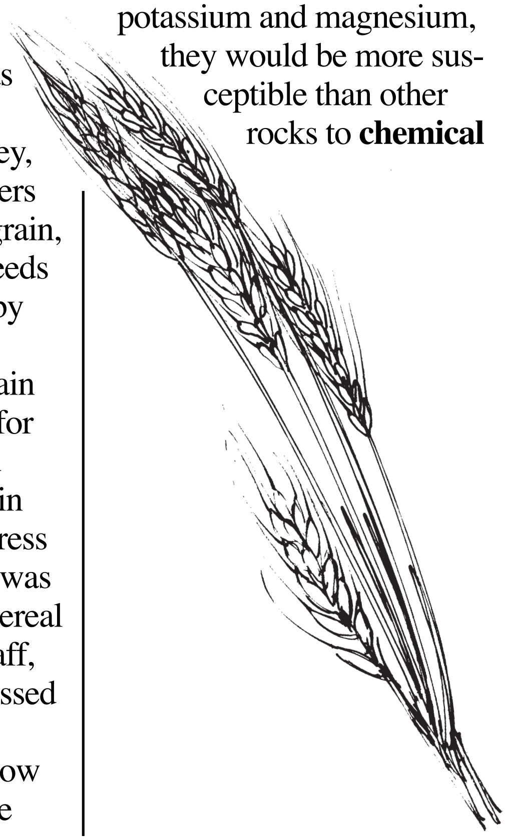
Years ago, this rock was used to thresh the wheat, rye, oats, buckwheat, barley, peas and beans local farmers harvested. To thresh the grain, they would separate the seeds from the rest of the plant by using a **flail**, made from a hickory sapling. The grain was then stored and used for food. The straw was used for livestock feed, placed in stables or used to fill mattress ticks. The threshing rock was also used to separate the cereal grains from the lighter chaff, or husk. The grain was tossed up into the air using a bed sheet. The wind would blow away the chaff, leaving the heavier seed kernels to fall back onto the sheet. This process is called winnowing.

Farmers also used rocks in the area for building fences, chimneys and support pillars to keep wooden structures away from termites and the rotting effect of moist soil and water. Many of these structures can still be seen at old home sites scattered throughout the park.

Stop 6: Rock Weathering

Read Aloud:

The odd pockets in these boulders show the strange shapes that weathering can produce. Why are the pockets shaped this way? Perhaps the matrix of minerals in these rocks is not as strongly held together as that of other boulders. For example, if the rocks had a higher concentration of potassium and magnesium, they would be more susceptible than other rocks to **chemical weathering** by carbonic acid, which is always present in rainwater. Notice the weathered **sediments** that have sloughed off the rocks onto the ground.



Stop 7: Rock Moss

Read Aloud:

The rock in front of you is covered with moss. Similar to Stop 3, this moss is helping to slowly weather the rock. Mosses also help prevent erosion and flooding by holding moisture from rains and melting snow. They can grow on soil, rocks, or even the bark of trees. Some prefer acidic, others alkaline soils. All lack roots and true stems; the leaves do not have veins as do the leaves of vascular plants.

Mosses grow from spores produced in capsules. When a spore lands on an area with sufficient moisture, the walls swell and a filamentous green thread (potonema) grows out. Rocks like this one are excellent hosts for such growth. The moisture captured in the contours of the rock enhance the spores' chances of germinating.

Stop 8: Rock Exfoliating

Read Aloud:

Notice the exfoliated slab of rock on the hillside above. This chunk of rock has been broken loose by ice wedging. Water that freezes each winter behind this rock has pushed the slab away from the boulder. The slab has broken free like a piece to a puzzle. Gravity also helped pull the rock slab down and away from the boulder.

Look for other rocks that seem to be exfoliating. Pay particular attention to lines or cracks that could one day expand and separate into slabs. Notice the different shapes and sizes of each rock or slab. No two are alike.

Stop 9: Alluvial Fan
Read Aloud:

This small, relatively flat **alluvial fan** has been made from soil that washed here from the steep hollow above.

All the water that flows through this fan is an example of a **watershed**. A watershed is the land area from which surface runoff drains into a stream channel, lake, reservoir or other body of water. Look for any areas where **deposition** is occurring. Are all the deposited materials the same size and shape? What are the primary erosional forces causing the deposition? (Running water and gravity.)

Stop 10: Ridge Top
Read Aloud:

The soil on this ridge is richer and deeper than the soil found in the boulder area. The white oaks growing here are evidence of this, for they require better soil than chestnut oaks do, which dominate the boulder area. This ridge divides two small watersheds.

Stop 11: Spring
Read Aloud:

Water falling from the sky in its many forms either evaporates, runs off the land into bodies of water, or is absorbed into the ground. Once in the ground, the water seeps into cracks in rocks, creating a water table. People who live in the country often get water from wells that are drilled into these rocks.

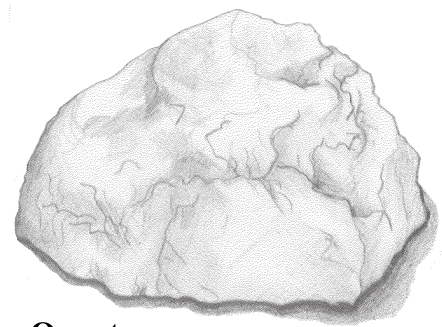
Springs are also a source of water. A spring occurs when the water table reaches the land's surface. The water in a water table generally contains **minerals**, such as iron or copper that have **leached** from the rocks.

The average temperature of water coming from a spring in this area is 55 degrees F. Before electrical refrigeration, mountain families often built a stone structure around a spring, called a "spring house," where they would store food to keep it cool.

Stop 12: Creek Convergence
Read Aloud:

Several small creeks or streams come together in this area, forming a small marsh. The ground is squishy under foot. Ferns and sphagnum moss grow very well here. Sphagnum moss can hold ten times its weight in water. This characteristic, and the fact that it is naturally sterile, is why the moss was once used to dress wounds on battlefields.

Look at the rocks in the water. Are they all the same? How do the rocks in the stream differ from the boulders just seen? Along the stream, notice all the **quartz** sand that has weathered and eroded from Stone Mountain. The dull, whitish gravel is the mineral **feldspar**. Using a hand lens, see if you can find small, glassy pieces of sand (**quartz**), black flakes (**biotite mica**), and copper-colored flakes (vermiculite, which is biotite that has absorbed water). The quartz sand is the most **resistant** mineral here, and is the only one durable enough to be carried by streams and rivers all the way to the ocean.


Quartz

Stop 13: Gravel Trail
Read Aloud:

As we start back along the trail through the field, look for signs of erosion. What has caused the trail to erode? Could it be something as simple as people hiking the trail? Thousands of hikers use this trail every year, creating an impact on the trail's surface that speeds up erosion by compressing the soil. This results in rainwater not being absorbed, but running off quickly, creating gullies. To slow down the erosion, the park staff has put in water bars, which are shallow ditches crossing the trail at an angle. These bars divert water from the trail before it can build up enough speed and force to gouge out gullies. The park staff has also put down gravel to increase traction so people don't slip, and to lessen the **compaction** of the soil.

Even though this trail shows erosion and compaction problems, it is still very important to stay on the trail. The erosion damage would be far greater if all the hikers were to scatter across this area. By keeping on the trail, the impact can at least be localized and monitored.

Stop 14: Stone Mountain Vista

Teacher Instructions:

Once you reach the open field, review what you've learned about:

- the cyclic process of bare rock succession;
- uses of rocks by early European settlers to the region, compared to how we use the rocks today; and
- weathering and erosion forces, using at least five examples from the hike.

Assessment:

Pencil and Paper Quiz –

1. Describe five factors that help to weather the granodiorite at Stone Mountain.

2. List five agents of erosion.

3. Give at least three examples of how early settlers used the rocks in the area around Stone Mountain. How do people use these rocks today?

4. Describe bare rock succession at Stone Mountain. (Students can use words or drawings, or a combination of these techniques.)

Extensions:

1. Visit the Hutchinson Homestead (see page 1.3) to learn more about how people in the 19th century lived on, and worked the land in rural North Carolina.

2. Hike the other trails in the park, especially the one going across the top of Stone Mountain and the trail across Wolf Rock. What evidence of weathering and erosion can the students find?

3. Once the group has returned to school, take a short walk around the school grounds looking for signs of weathering and erosion. Discuss what forces cause the erosion they see. Also discuss ways people can help slow down the erosion. The class may even find an erosion problem they can correct as a class project.

4. The students may want to create their own trail booklet that will help other students to enjoy the geological processes that can be seen on their school grounds. Have students use the booklet to guide younger students or parents around the school.

Note: In order to create this booklet, students will need to do some research about the geology of their area and past uses of the land. If desired, students can learn how to make a map and mark the trail stations on it.

Student's Information - Part II

When we think of **rock**, we think of a material that is very hard, almost indestructible. When we think of mountains, we think of massive features that are unchanging. But, this isn't at all the case. All landforms on earth, from mountains to river valleys to the coastline, are constantly changing. As some landforms are being slowly worn away, new ones are building up at the same time.

Two forces, **weathering** and **erosion**, constantly wear away at the rocks that make up the earth's crust. Weathering causes rocks to crack, fragment, crumble or break down by physical and/or chemical means. Erosion loosens and carries away the rock pieces produced by weathering. Over millions of years these two forces, working together, have changed our land and will continue to do so millions of years into the future.

Weathering:

All rocks weather, but not at the same rate. Some rocks will weather much faster than others. The rock's **minerals** determine the rate at which it weathers. Climatic factors, such as rainfall, also play a role.

Here are five examples of weathering that you can see at Stone Mountain State Park:

1. Ice Wedging: When water runs into cracks in rocks and freezes, the ice expands. As the ice expands, it pushes against the rock and exerts force and pressure. This eventually causes the rock to break apart.

2. The Hot-Cold Cycle: The daily change in temperature from cool nights to warm days can result in very slight expansion and contraction that, over time, will cause rocks to crack and break apart.

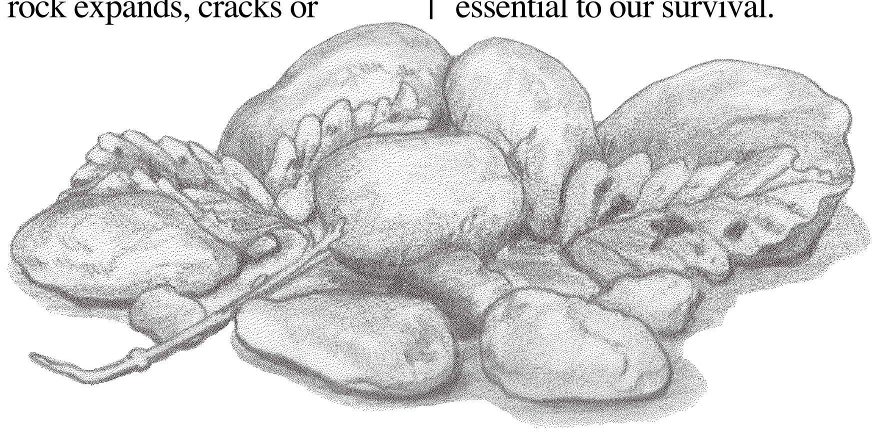
3. The Roots of Destruction: Plants play a role in breaking rocks apart. As small amounts of soil gather in rock cracks, any seeds deposited there by wind, birds and other animals, will start to grow. As a plant's roots expand into the cracks, they put pressure against the rock. This forces the cracks to widen, eventually splitting the rock apart.

4. Exfoliation: Another type of weathering found in massive rocks, such as **granodiorite**, is caused when the rock expands after erosion has removed the weight of overlying materials. As the rock expands, cracks or joints form parallel to the surface. Curved sheets of weathered rock are eventually eroded away by running water and/or gravity. The rock resembles a peeling onion.

5. Chemical Breakdown: Some minerals change as they react with the chemicals in air and water. Dead and decaying matter such as leaf litter forms humic acid. Even rainwater is acidic. These acids help weather rock.

Not all minerals react to chemicals in the same way. Irregularly rounded depressions, called **weathering pits**, pockmark the surface of Stone Mountain. These weathering pits form when some minerals weather more rapidly than others. Water, with its carbonic acid, collects in these pits, and causes additional **chemical weathering**.

Without weathering, we couldn't survive. As rocks are continually broken down into smaller parts, they eventually become fine enough to be called silt or sand, two very important ingredients of soil. This soil is essential to our survival.



Erosion:

Erosion involves forces that continue the work started by weathering. Erosion helps to loosen particles and move weathered rock material. Here are five agents of erosion:

1. Moving water: Water does more to wear away our land than all other geologic forces combined. A fast flowing stream will carry a lot more than just water. Soil, sand, silt and rocks can all be carried by fast flowing water. Notice a stream after a hard rain and you will see erosion in action.

2. Wind: Wind erodes by lifting and removing dry, fine particles that are sand-sized or smaller.

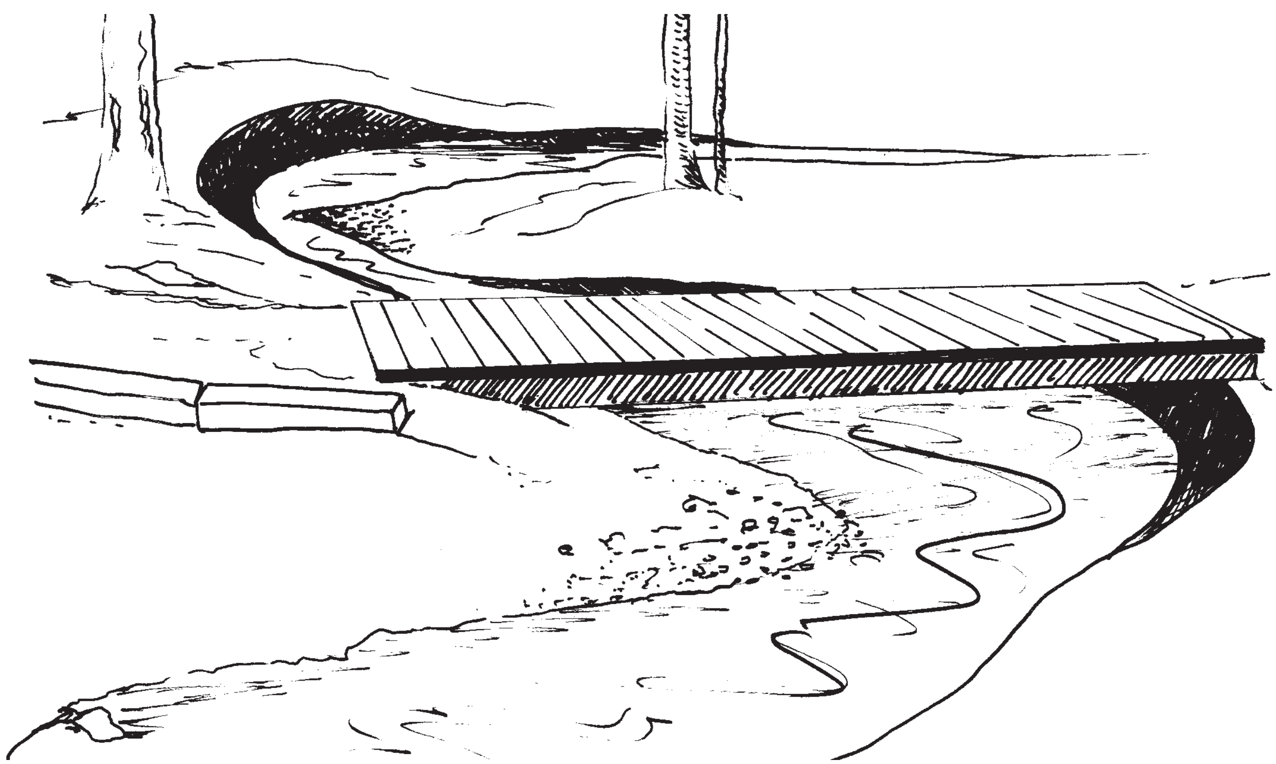
3. Ice: Ice is the one force of erosion that we don't see very often in our area of the world. In the colder regions, snow may pile up hundreds of feet thick, forming a great sheet of ice called a glacier. Glaciers from past ice ages have shaped much of the world's landscapes, but not North Carolina's.

4. Gravity: Gravity moves weathered rocks, especially on steep slopes. The boulders at the base of Stone Mountain tumbled here after being exfoliated from the rock above.

5. People: People constantly modify the landscape. We cut forests, drain swamps, fill in wetlands, mine for minerals, and build houses, shopping centers, landfills, farms, etc. The land, once cleared, is open to the erosional forces of water and wind. All the changes people make to the earth's surface affect the natural patterns of weathering, erosion and **deposition**.

As weathering and erosion constantly wear away our earth's crust, other forces are at work building it up. Mountains, **volcanoes** and **faults** are formed as rocks are pushed up, warped, folded or fractured due to great force and pressure deep within the earth. Water, wind and ice can also build up areas by carrying **sediments**, which are produced by weathering and erosion, and dumping them in another area. This buildup, or deposition, creates new landforms.

Mountains are created and leveled, valleys dug out and filled in, seas born and dried to dust. The earth is constantly changing – nothing remains unchanged but the agents of change themselves.



On-Site Activity #2 Mineral Detectives

Major Concepts:
- Minerals
- Mineral identification
- Properties of minerals

Learning Skills:
- Observing, classifying, inferring
- Reading a scientific key

Subject Areas:
- Science
- English Language Arts

* See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

Location:
Stone Mountain State Park picnic shelter

Group Size:
30 students or less

Estimated Time: 1 hour

Materials:
Provided by the educator:
Per student: One copy of Student's Information and Mineral ID Key, paper and pencil
Provided by the park:
Mineral specimens, testing equipment, balance, streak plate, hardness indicators—penny, steel nail, steel file, emery cloth – safety goggles, and geologist's hammers.

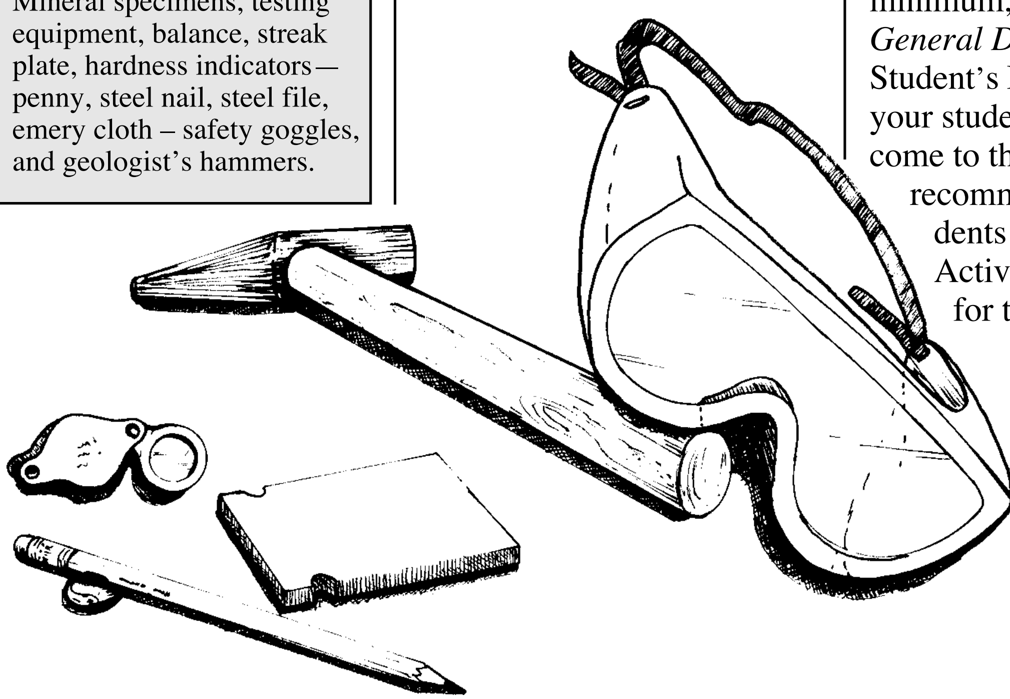
Objectives:

- Name at least four physical characteristics that help geologists classify minerals.
- Demonstrate the ability to correctly and safely perform tests for hardness, cleavage, and streak on several different mineral samples.
- Use observation skills and an identification key to classify at least five unknown minerals.

Educator's Information:

Minerals are identified using various physical characteristics, such as **hardness**, color, **streak**, **luster**, specific gravity, and **cleavage**. Magnetic properties, **fluorescence** and odor are also used to classify a number of minerals. In this activity, your students will learn about some of these characteristics and their common field tests. At the park, your students will work in teams to identify unknown mineral samples. Note: Several of the minerals used in this activity are *not* found in the rocks at the park.

You may want to duplicate the Student's Information in this activity and review it with your students before coming to the park. At a minimum, please read the *General Directions* in the Student's Information to your students before they come to the park. We also recommend that your students complete Pre-visit Activity #3 to prepare for this on-site activity.



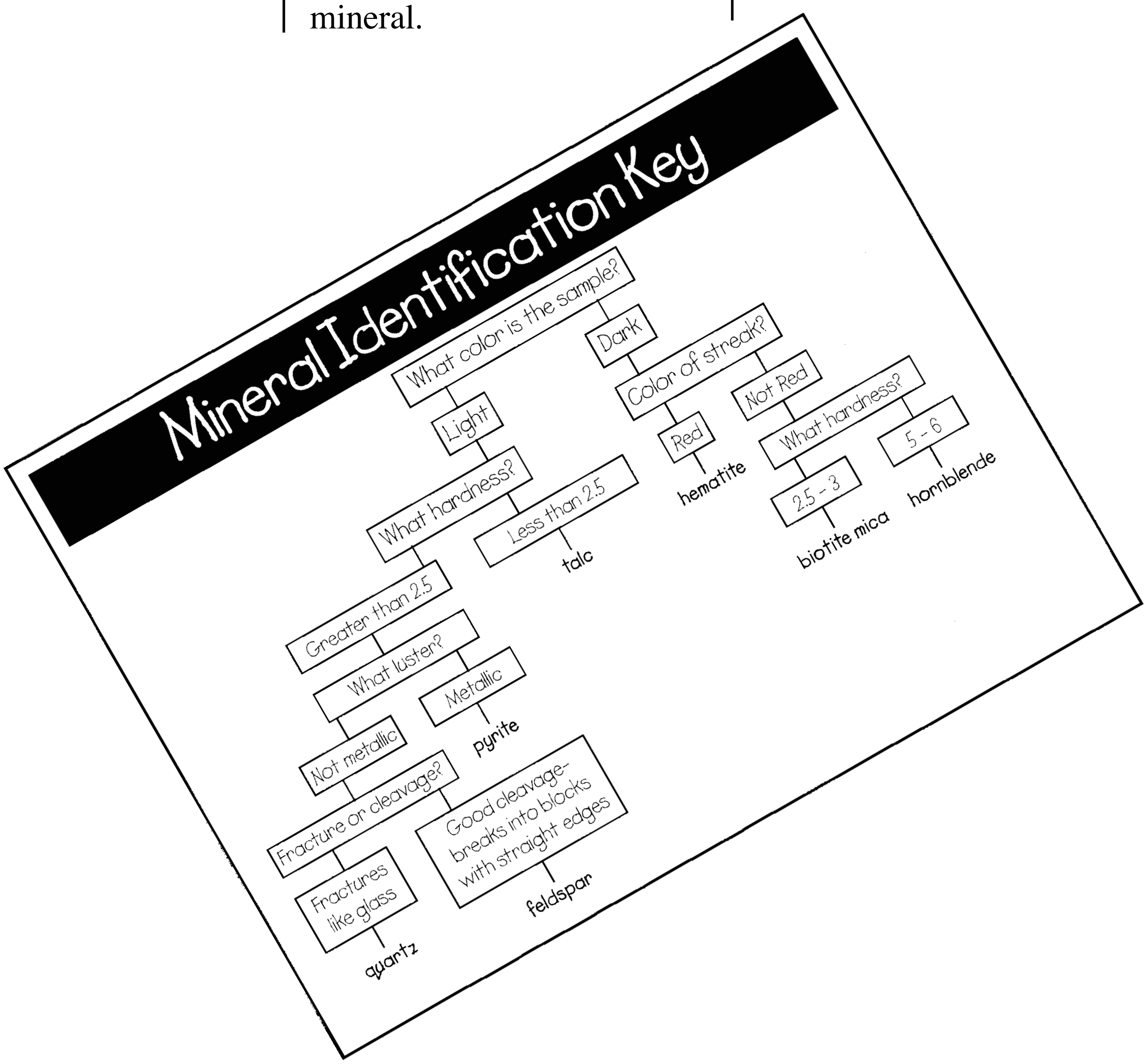
Instructions:

1. At the park, the teacher and/or ranger should demonstrate the various mineral identification techniques described in the Student's Information. Tell the students that they will be identifying unknown minerals using some of the techniques demonstrated. After the demonstration, divide the students into small teams. Give each team a collection of unknown mineral samples, the Mineral Identification Key, and mineral identification tools.

2. Instruct the teams to examine one unknown mineral sample at a time. They should follow the arrows on the Mineral Identification Key to find the correct name of the mineral. Each time they answer a question in the key, the arrows will lead them to the next question, and finally to the name of the mineral. For each specimen, they should write down their choices as they answer the questions in the key. The last answer choice should be the name of the mineral.

Assessment:

Back in the classroom, provide the students with a different set of unknown minerals. Ask students to work in their teams to perform mineral identification tests such as hardness, cleavage and streak. They should record their answers for each mineral. You can give them a key to help them identify the minerals, or ask them to create their own key.



General Directions:

Look around your class. You will notice that everyone looks different. Some people are short, some are tall. Some people have blonde hair, while others may have black hair. These differences are called physical characteristics and they help you tell each other apart. **Minerals** also have physical characteristics that distinguish them. Instead of hair color or height, minerals are identified by **hardness**, color, **streak**, **luster**, and **cleavage**. Some minerals can also be identified by their smell, **fluorescence**, and magnetic properties. Geologists have developed tests for each of these physical characteristics. Although some of the tests have to be done in a lab by a professional, most of the tests are easy enough to do in the field.

When you visit Stone Mountain State Park, you are going to learn about each of these characteristics and how to test for them. You will also be given unknown minerals and asked to identify them.

MINERAL CHARACTERISTICS:

HARDNESS

The hardness of a mineral tells how well it scratches other materials. All minerals have been given a hardness between 1 and 10. 1 is the softest, while 10 is the hardest. Frederick Mohs, a German scientist who was born over 100 years ago, developed the hardness scale. He took 10 common minerals with different hardnesses and assigned them values between 1 and 10. The softest mineral, talc, was assigned a 1. Talc is the mineral that is used in baby powder. The hardest mineral, a diamond, was assigned the 10. A mineral with the hardness of 7, such as quartz, can scratch all minerals below 7 on the hardness scale. Quartz can be scratched by all minerals with a hardness of 7 or above.

Mohs Hardness Scale

softest	1	talc
	2	gypsum
	3	calcite
	4	fluorite
	5	apatite
	6	orthoclase feldspar
	7	quartz
	8	topaz
	9	corundum
hardest	10	diamond

To be very precise in measuring hardness, you would need each of the 10 minerals. Then, you would see how many of the minerals could scratch the unknown mineral you were testing. For instance, suppose you found a mineral that could be scratched by a diamond, corundum and topaz, but it could scratch all of the other minerals in Mohs' hardness scale. A good estimate for the hardness of that mineral is 7.

Sometimes, it might be hard to find or carry all of the minerals in Mohs hardness scale. **Geologists** use some simpler equipment, especially when they are in the field. Look at the field hardness scale below to see how many of these items you already have.

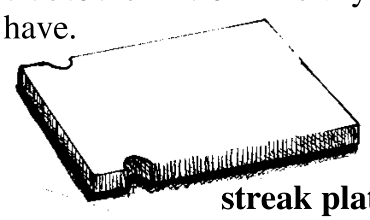
Field Hardness Scale

2.5	Fingernail
3	Penny
5.5	Steel nail
6.5+	Hardened steel file
8-9	Emery cloth

Start with your fingernail. If you cannot scratch the sample, you know that it has a hardness greater than 2.5. Next try the penny. If the penny can scratch the sample, then you know that the sample has a hardness between 2.5 and 3. If the penny cannot scratch the sample, then you know that the sample has a hardness greater than 3. Keep trying the different items listed on the field hardness scale until you find one that scratches the sample. Be sure to start with the lowest hardness (fingernail) and move up (penny, then nail, then steel file and so on), until you find a material that will scratch your sample. This will give you a rough estimate of the hardness of your sample.

COLOR

The color of a mineral is usually its most distinctive physical characteristic. However, you cannot identify a mineral by color alone. Many times, a mineral's color is caused by chemical impurities in quantities too small to affect the basic chemical composition of the mineral. Quartz is one mineral that comes in all different colors. Even though color alone is not enough to identify a mineral, pay attention to the color. It will provide at least one clue to the kind of mineral you have.

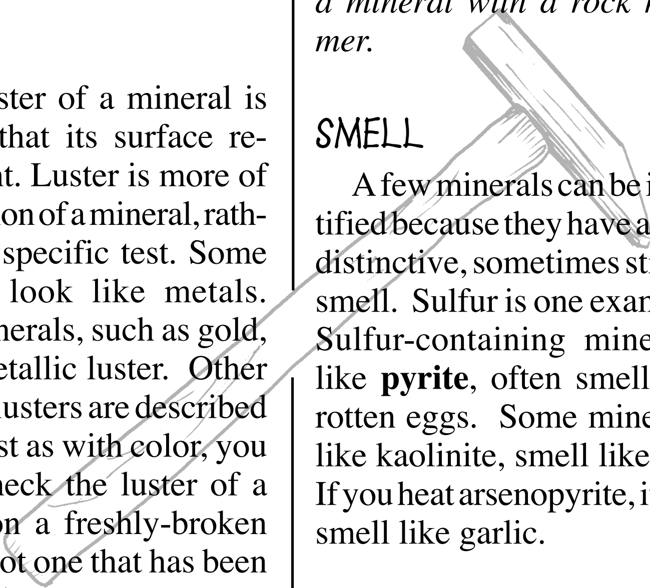


streak plate

STREAK

If you took a mineral and pulverized it, the color of the mineral powder is known as its streak. Sometimes the streak of a mineral is not the same color as the mineral itself. An easier way to test streak, rather than grinding up the mineral, is to rub the mineral on a piece of unglazed tile. This tile is known as a streak plate. Sometimes, a mineral will not leave a streak on the plate. This is because the mineral is harder than the streak plate (6.5).

LUSTER



The luster of a mineral is the way that its surface reflects light. Luster is more of a description of a mineral, rather than a specific test. Some minerals look like metals. These minerals, such as gold, have a metallic luster. Other common lusters are described below. Just as with color, you should check the luster of a mineral on a freshly-broken surface, not one that has been weathered.

Adamantine: brilliant and shiny, like a diamond

Glassy: looks like glass

Resinous: looks like plastic

Greasy: looks like the surface is oily

Pearly: looks like a pearl

Silky: looks like silk or rayon

Dull: has a rough surface, or a surface with no luster

CLEAVAGE & FRACTURE

Cleavage is the ability of a mineral to break along one or more smooth, flat lustrous surfaces, called planes. If a mineral breaks easily in one or more directions, it has cleavage. Feldspar is a good example of this. When some minerals break, they may have a jagged or irregular appearance. Geologists call this **fracture**. Quartz is a good example of a mineral with fracture.

CAUTION: *Always wear safety goggles when breaking a mineral with a rock hammer.*

SMELL

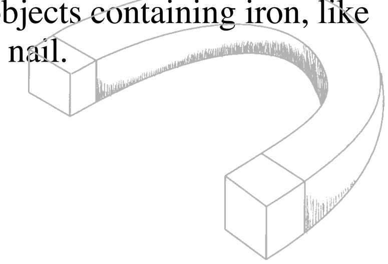
A few minerals can be identified because they have a very distinctive, sometimes stinky, smell. Sulfur is one example. Sulfur-containing minerals, like **pyrite**, often smell like rotten eggs. Some minerals, like kaolinite, smell like dirt. If you heat arsenopyrite, it will smell like garlic.

FLUORESCENCE

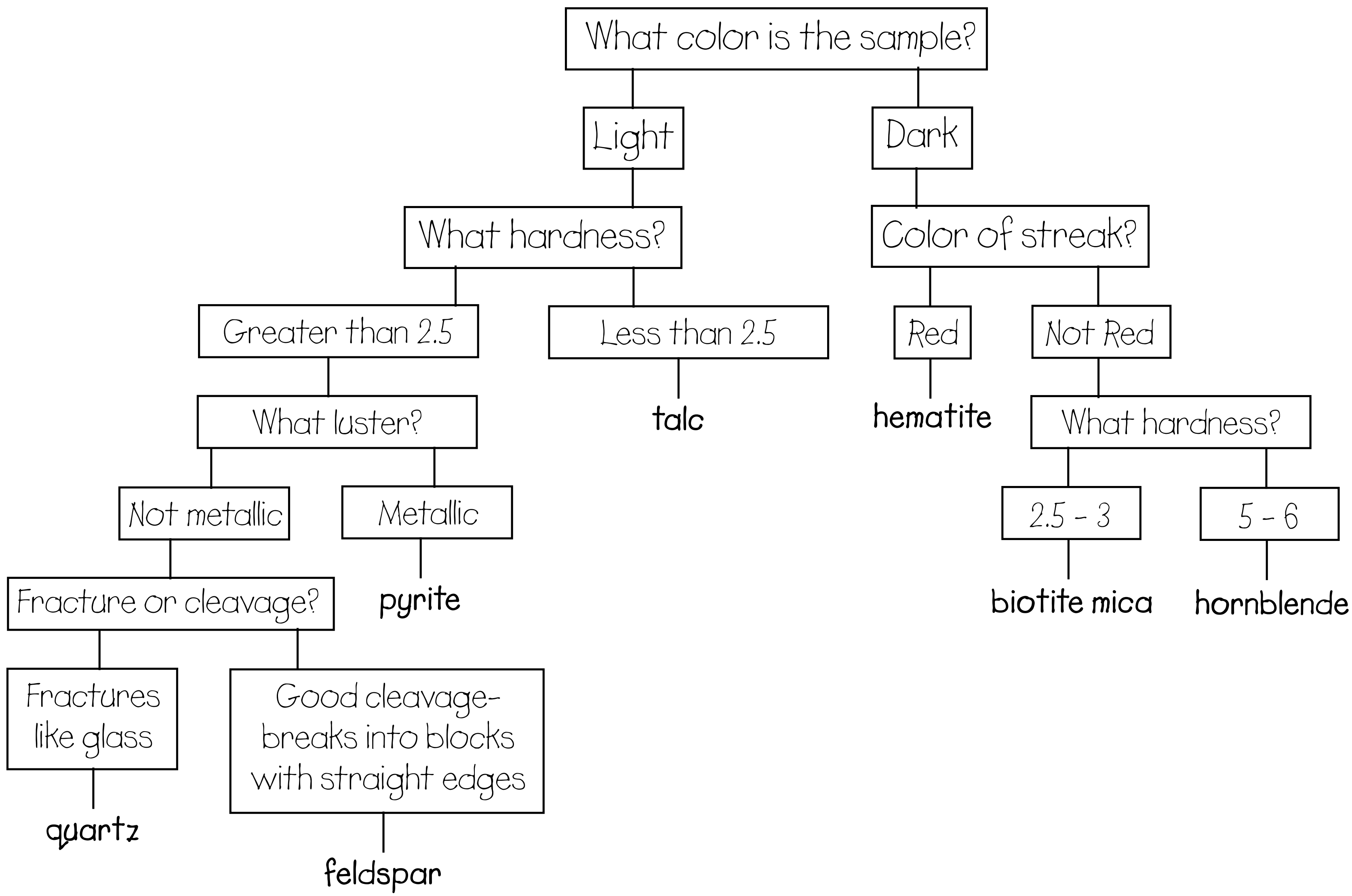
Many minerals will glow when they are placed under an ultraviolet, or "black" light. Many different minerals have fluorescence and some minerals will glow in several different colors. For this reason, fluorescence alone cannot identify a mineral. However, it can provide valuable clues to a mineral's identity.

MAGNETISM

Some minerals that contain iron will be attracted or repelled by a magnet. Others, like lodestone, are natural magnets and will attract objects containing iron, like a nail.



Mineral Identification Key



On-Site Activity #3 Exploration to the Falls

Major Concepts:
- Intrusive igneous rocks
- Landforms
- Stream features
- Weathering and erosion

Learning Skills:
- Observing, classifying, communicating, inferring
- Collecting, analyzing and evaluating information
- Measuring

Subject Areas:
- Science
- English Language Arts
- Social Studies
- Mathematics

* See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

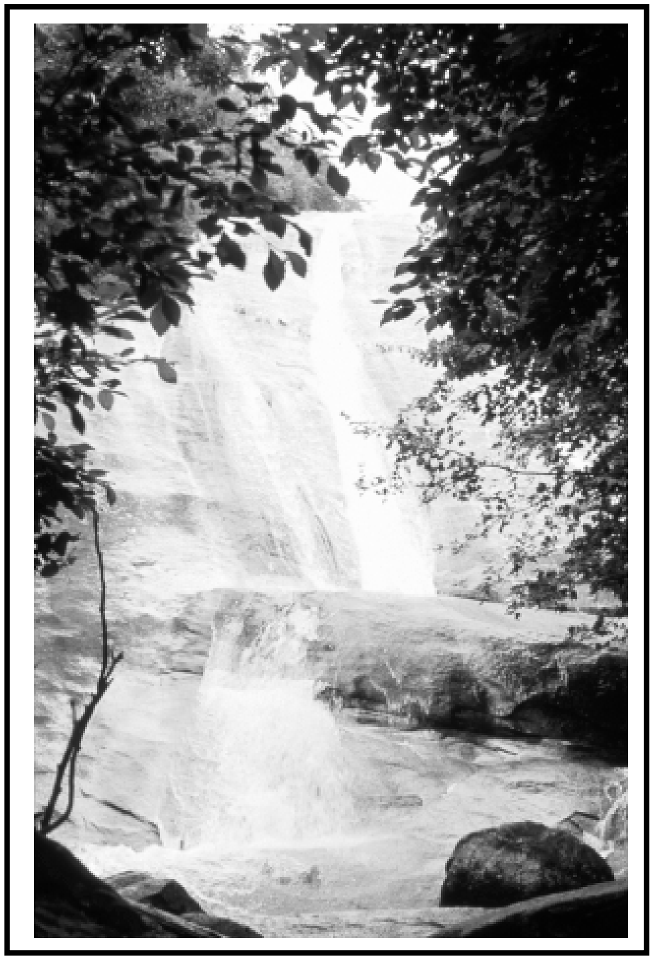
Location: Stone Mountain Connector Trail and Stone Mountain Loop Trail

Group Size: 30 or less, preferably in groups of 10 or less with a minimum of one adult leader per group

Time: 1-2 hours

Appropriate season: Spring, summer, fall

Materials:
Provided by the school:
Per adult leader: one copy of *Exploration to the Falls Geology Field Notebook*
Per class: one first aid kit and water bottle
Per student or group: one copy of *Exploration to the Falls Geology Field Notebook* or other field notebook, measuring tape, field compass, pencil, hand lens



Special Considerations:
Leaders should scout the trail ahead of time to become familiar with recommended stops and to recognize potential hazards such as slippery rocks, steep slopes, poison ivy, etc. Take special note of the cautions given in the geology field notebook in this activity. Leaders should carry a first aid kit and water bottle for emergency use.

Objectives:
- Describe how intrusive igneous rocks are formed and name the igneous rock at Stone Mountain.
- Name at least three minerals found in granodiorite.
- Gain an appreciation for the geologic formations in Stone Mountain State Park.
- Describe at least three weathering features in the granodiorite including weathering pits, exfoliation sheets and differential weathering.
- Explain how the dome-shaped appearance of Stone Mountain developed over time.

Educator's Information:

This activity is a hike with nine different stops on the Stone Mountain Connector and Stone Mountain Loop trails. Students will be able to explore firsthand the **geology** of Stone Mountain. This moderately difficult hike originates in the picnic area and ascends to the top and bottom (if you wish) of Stone Mountain Falls. You will return to the picnic area by the same route. Consult with park staff to learn about alternative routes, difficulty levels and potential hazards.

We recommend that the students study a geologic map of North Carolina along with the maps and information provided in this EELE beginning on page 1.7. We also recommend that older students make *quantitative* observations at the stops along the trail. The teacher should provide the appropriate equipment such as field compasses and measuring tapes.

You can use the geology field notebook (provided in this activity) with your students, or follow a more inquiry-based approach. For an inquiry-based approach, a good seed question might be: " Why is Stone Mountain round or dome-shaped?" Students would observe, sketch and measure the geologic features at the nine stops on the hike. You would encourage them to form their own explanations for what they observe. And, with thoughtful questioning, you would guide them to make further observations and to look for connections. By exploring how granodiorite weathers on a small scale, can they imagine how these weathering processes could have formed the big dome of Stone Mountain over time?

An overview of the hike follows:

- **Stop A** - Students explore a **pavement outcrop**, observe plant succession in progress, and examine several **weathering** features in the **granodiorite**, such as **weathering pits** and **exfoliation sheets**. If desired, you might ask students to measure the weathering pits or use a compass to check the orientation of cracks in the rock. Hands lenses would be helpful for studying the minerals in the rock, investigating the stains on the rock, or studying lichens and mosses.
- **Stop B** - This stop is useful only when the foliage is off the trees. Students can observe Stone Mountain from a distance and speculate about how weathering processes shaped its rounded top. You might also discuss how the granodiorite **pluton** (of which Stone Mountain is a small part) formed in the distant past. (See On-site Activity #1.)
- **Stop C** - Students examine **parallel sheet joints**, **vertical fractures**, and **differential weathering** in slabs of rock. Use caution in hiking down the hillside to this outcrop and watch out for copperheads, which may lurk in cracks or under rocks. The interaction of tree roots with this outcrop is quite interesting.
- **Stop D** - Students observe Big Sandy Creek and discuss its origins. By exploring the rocks found in the stream, they will learn the role water plays in weathering and erosion. Many of the rocks in this stream are not granodiorite, but are the **gneisses** and **schists** of the **Alligator Back Formation**. Use the map provided in the Introduction section of this EELE to discover where the different rocks may have come from.
- **Stop E** - Students observe a chimney and consider how humans rely on rocks and minerals in their daily lives. This is a good time to discuss how the geology of Stone Mountain has influenced humans through the ages. Students can also look for **feldspar**, **quartz** and **biotite** in the chimney stones.
- **Stop F** - Students observe the top of Stone Mountain Falls near a **knickpoint**. *Make sure everyone stays behind the fence! Venturing over the fence and near the stream may result in a deadly fall!* This is a good spot to show human impacts on rocks and plant succession. Compare the lichen growth on each side of the fence.

• **Stop G** - Students examine a **dike.** This feature formed when magma filled a crack in the granodiorite. Because the composition of the dike rock is similar to the composition of the surrounding granodiorite, it is likely that the dike formed shortly after the granodiorite in the pluton had cooled enough to begin cracking. Note that the dike is standing above the surrounding rock. Although the composition may be similar, the dike rock is more resistant to weathering and erosion than the granodiorite it has intruded. Students can also explore the crack or joint that runs alongside the dike and consider any relationships between the two features.

• **Stop H** - Students observe slabs of granodiorite that have fallen down the slope (**mass wasting**). The viewing platform at this stop represents the midway point of Stone Mountain Falls, which is technically called a **cascade.** Students can observe how the water is in contact with the rock here.

• **Stop I** - If you choose to walk to the bottom of the falls, you will have 307 steps to climb on your way back up! Here, students can study the shallow pool at the bottom of the falls and observe how water has carved the granodiorite. Slabs of rock that have broken off the main mass litter the area. The water continues to cut into and erode the granodiorite; thus, the cascade slowly recedes upstream.

Instructions:

1. Before bringing students to Stone Mountain State Park, study the *Exploration to the Falls Geology Field Notebook* in this activity. Visit the park to scout the trail yourself. Ideally, this should be done at least one week prior to your class' visit and at the same time of day. This will help you become familiar with the exact locations of the stops described in the field notebook and potential trail hazards such as slippery or steep areas, etc.

2. Optional: Copy the *Exploration to the Falls Geology Field Notebook* for each student and adult leader.

3. Take the students to the picnic area where the hike will begin. Divide the class into smaller groups of ten students or less. Provide one adult leader per small group.

4. Distribute the *Exploration to the Falls Geology Field Notebook* and other equipment (see Materials on page 4.3.1) as desired.

5. During the hike, one of the group leaders should carry the first aid kit and water bottle. Make sure everyone knows which group has the first aid kit and water bottle in case of emergency. Each student should have a "buddy" in his/her group. Each leader will be given a small litter bag to help with trail cleanup.

6. Begin the hike with a brief introduction during which you cover topic, trail distance, time, difficulty and special rules. Here are some special rules to teach your students:

a. Stay on the trail until told otherwise.

b. Watch for roots, stumps, sloped walking areas and other hazards. *Running is not allowed. Walk carefully on the rock outcrops.*

c. Rock climbing is not permitted except in areas where told otherwise. No rocks are to be removed from the park.

d. All plants and animals within the park are protected. Injuring and removing plants or animals are prohibited in all state parks. This allows future visitors the same opportunity to enjoy our natural resources.

e. Being quiet will help you see more wildlife.

f. The adult leader should always be at the front of the group.

g. Do not litter. When picking up litter along the trail, do not touch broken glass or other sharp objects.

7. When conducting the hike, start each small group at 5-minute intervals so the groups do not get too close to one another. Make sure all the leaders know the amount of time they have to conduct the hike and visit all the stops. All groups should have a designated place to meet at the end of this activity.

Remind leaders that when pausing for discussion or to view an interesting object along the trail, they should lead their group halfway beyond the object so all will have a good view.

Assessment:

After you return to the classroom, ask the students to write the answers to the following questions:

1. Name at least three minerals found in granodiorite.

(feldspar, quartz, biotite, hornblende)

2. Explain how the exfoliation dome of Stone Mountain may have formed.

(See page 1.7 in this EELE or On-site Activity #1.)

3. Describe at least three examples of weathering that you observed on the hike.

(a. Differential weathering where some minerals in the rock weather faster than others. The more resistant minerals stand a few centimeters above the less resistant minerals.

b. Exfoliation sheets where the rock expands and cracks parallel to the earth's surface. The thin layers peel away like the skin on an onion.

c. Weathering pits where water has carved holes in the rock.)

4. Describe in two or three sentences your favorite geologic feature at Stone Mountain. Or, which was your favorite trail stop and why?

(Answers will vary.)

Extensions:

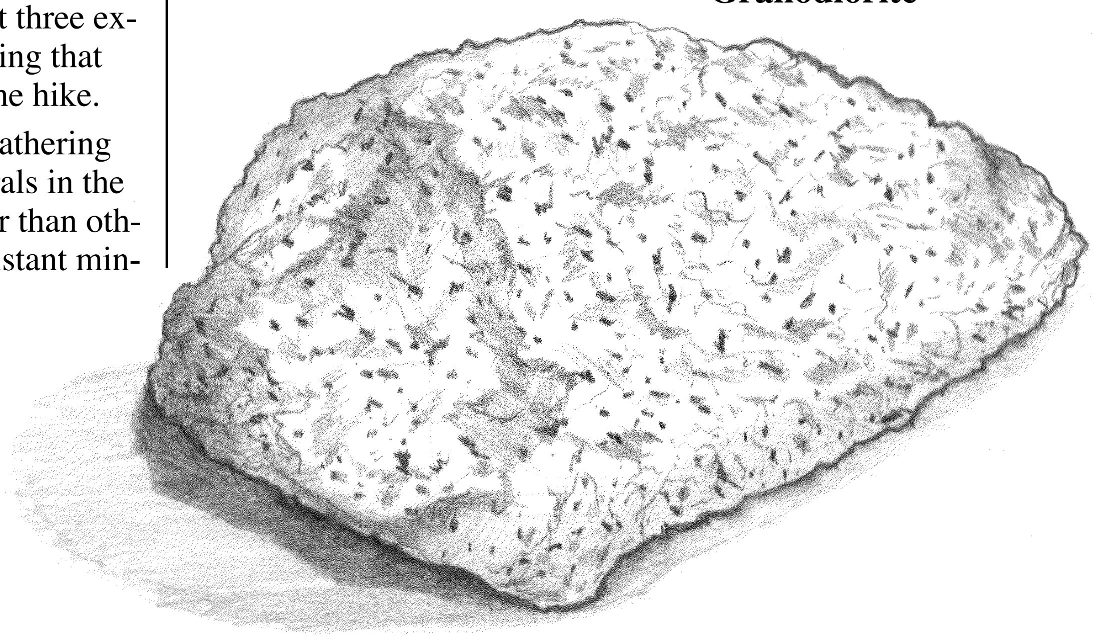
1. Complete the other two on-site activities in this EELE to learn more about classifying minerals and the geologic and cultural history of the area.

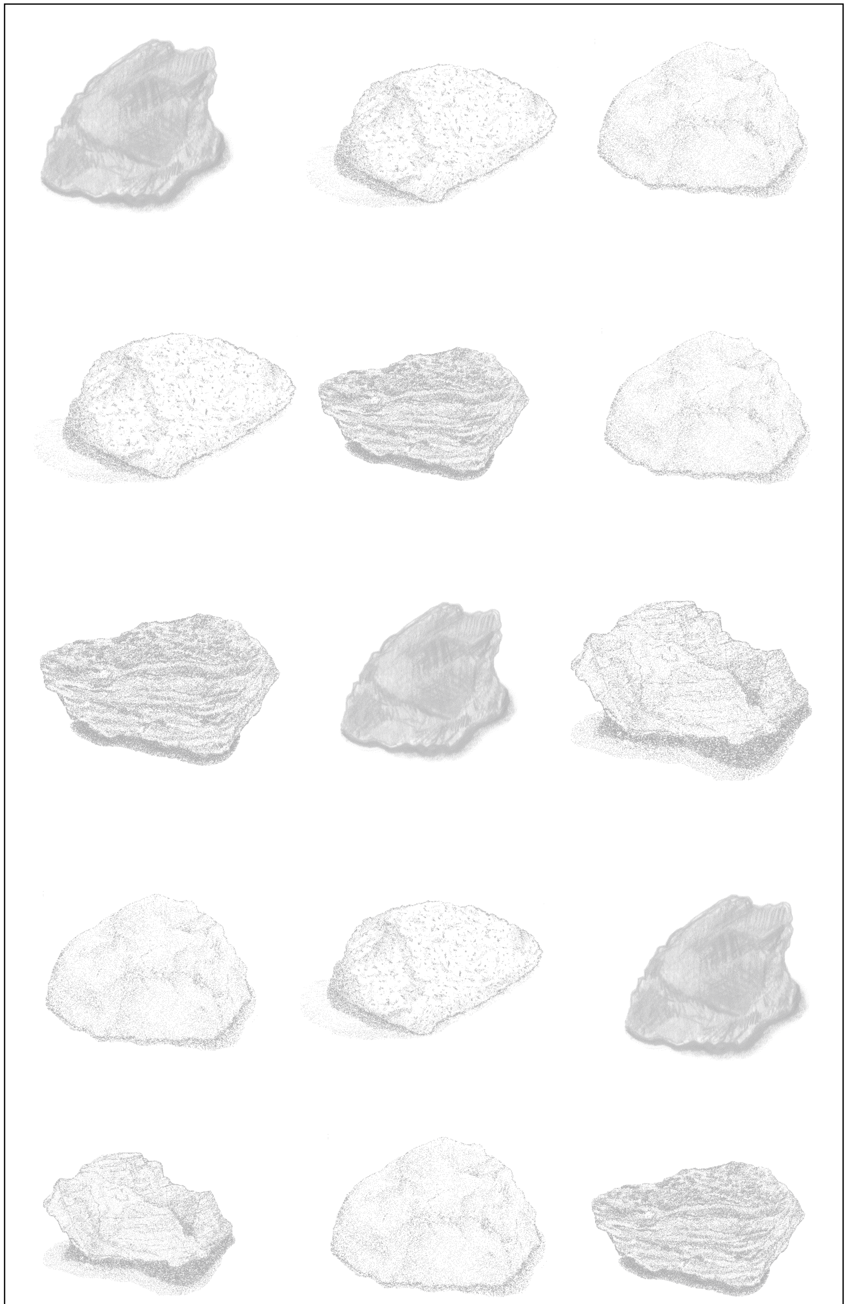
2. Create your own geology trail at your school.

3. As you leave the park, stop and view the road cut on the big hillside where the John P. Frank Parkway connects with state road #1002. This road cut contains granodiorite as well as the rocks (gneiss and schist) of the Alligator Back Formation. Locate this site on the map in the Introduction section of this EELE. How can you explain some of the features you see in the rocks of this road cut? You might ask your students to sketch some of the features.

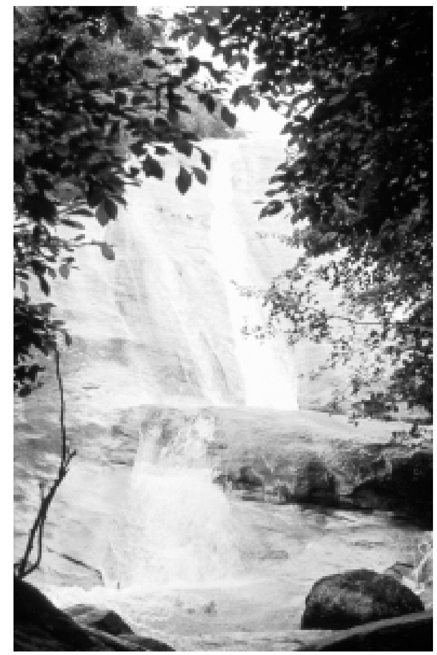
<u>Caution:</u> If you decide to collect or move rocks at this road cut, use the same precautions you should use at any road cut: Watch out for falling rocks. Wear a hard hat for safety. Watch for copperheads under rocks – use care when lifting rocks.

Granodiorite





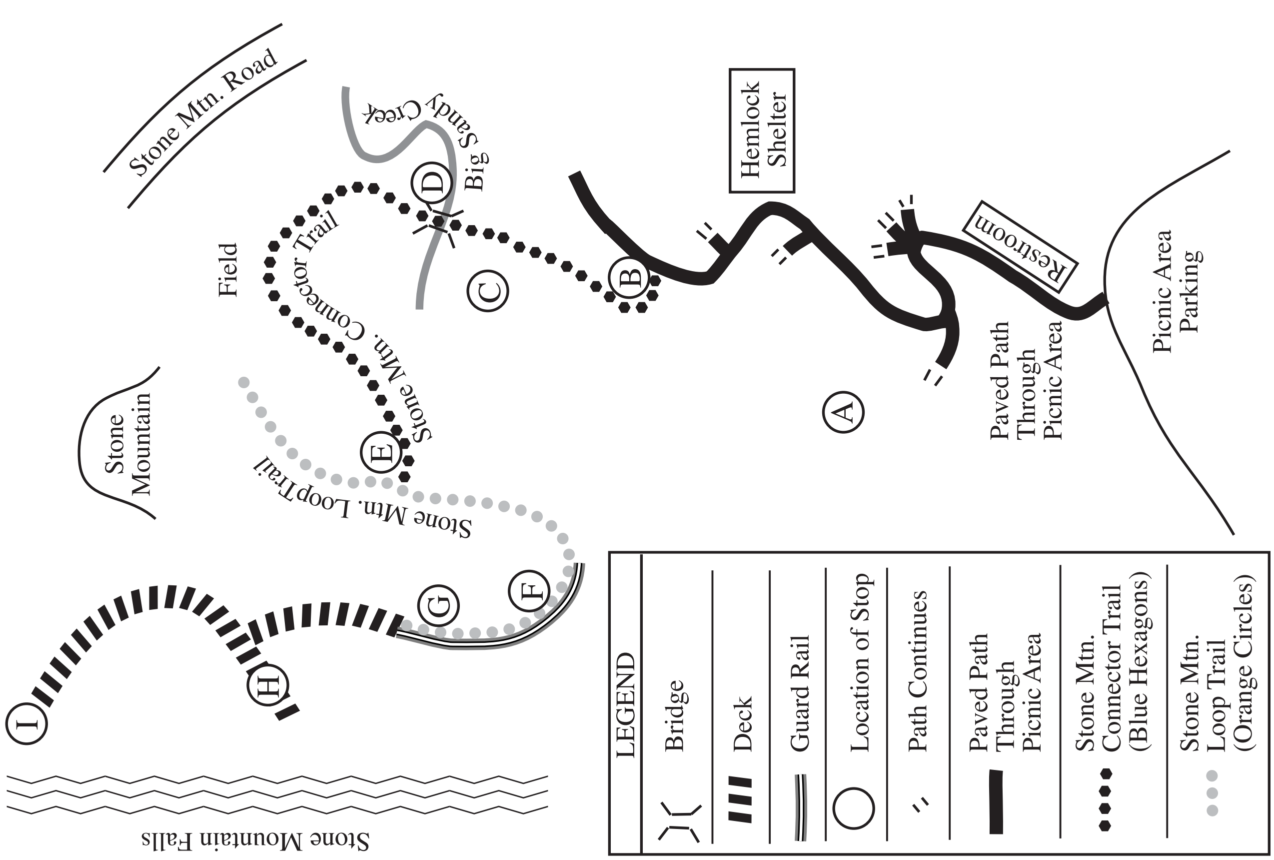
Exploration to the Falls



GEOLOGY Field Notebook

STONE MOUNTAIN STATE PARK

Map of Trail with Stops Pinpointed



Notes

Welcome to Stone Mountain State Park, an outdoor museum covering more than 700 million years of **geologic** history. Today, you will be hiking up to and along the Stone Mountain Connector and Stone Mountain Loop trails to explore some of the fascinating geologic features of the park, including Stone Mountain Falls.

The **rocks** of Stone Mountain consist mostly of **granodiorite**, a rock similar to granite but with *less* potassium feldspar and *more* plagioclase feldspar and dark-colored minerals. About 390 million years ago, during the Devonian period, a mass of **magma** formed several miles deep in the earth. This magma cooled slowly beneath the earth's surface forming a **pluton** of granodiorite, an **intrusive igneous rock**. Since then, millions of years of erosion have stripped away the overlying rock and exposed the granodiorite at the earth's surface.

As you explore the unique environment and ecosystems of Stone Mountain State Park, realize that this area did not always appear this way. **Geologists** are really detectives who study rocks for clues to the past. The old saying, "A picture is worth a thousand words," is certainly true in geology. By carefully examining the rocks, you'll be able to piece together some of the geologic story of Stone Mountain. And by studying the park's geology, you will also better understand the relationships between the rocks and the soil, water, plants and wildlife.

Stop A - Pavement Outcrop

LOOK FOR: Large exposed pavement outcrop below the restrooms and picnic area.

Caution: Walk carefully! Stay on the exposed rock and away from steeply sloping areas.

Geologists call bare rock exposures like this one **pavement outcrops**. Granodiorite pavements give Stone Mountain its distinctive appearance.

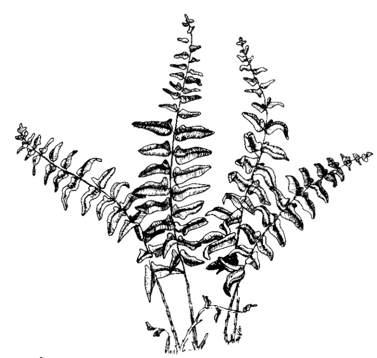
Notice the **weathering pits** – irregular depressions in the rock. Weathering pits form as some minerals in the rock decompose more rapidly than others. As water continues to collect in these pits on the rock surface, they slowly enlarge, merge with others, and form the characteristic "pock-marked" surface of the rock pavement.

The plant communities and soil that eventually develop on these pavements begin when lichen and moss colonies establish a "toe hold" in the weathering pits. These plants produce organic acids that help to decompose the minerals in the rock. As the rock breaks down, a thin layer of soil is produced and grasses and flowers start to grow. Gradually the soil becomes thick enough to support trees.

As you hike back to the picnic area, recall the clues in the rocks that help us to learn about past geologic history. The mineral composition and texture of the granodiorite provide evidence of powerful earth forces that created a giant pod of magma deep in the earth. This magma cooled slowly enough under the earth's surface that mineral grains, large enough to be seen, were formed in the rock. A coarse-grained, intrusive igneous rock called granodiorite resulted.

Joints, weathering pits, differiential weathering and exfoliation sheets reveal how the smooth dome of Stone Mountain took shape over time. If Stone Mountain were made of a different type of rock, do you think it would look the same today? Why or why not?

Recall the plants and animals you viewed on your hike. How does the geology of the area affect them?



Stop I - Bottom of Falls

LOOK FOR: Pool at bottom of falls and large boulders in stream.

Note: *If the group is up for hiking all the way to the bottom of the falls and then back up to the top, you can explore the bottom of the falls. You'll be climbing 307 steps on your way back to the top of the falls!*

Water carved this shallow pool out of the rock at the bottom of the falls. It provides a habitat for fish and other aquatic life.

How do the trees and other plants here compare with those at the top of the falls?

The large boulders you see at the bottom of the falls and further downstream weren't always here. These large rocks likely broke off the side of the face of the waterfall. Over time, the cascade has slowly receded upstream.

Stops A & B

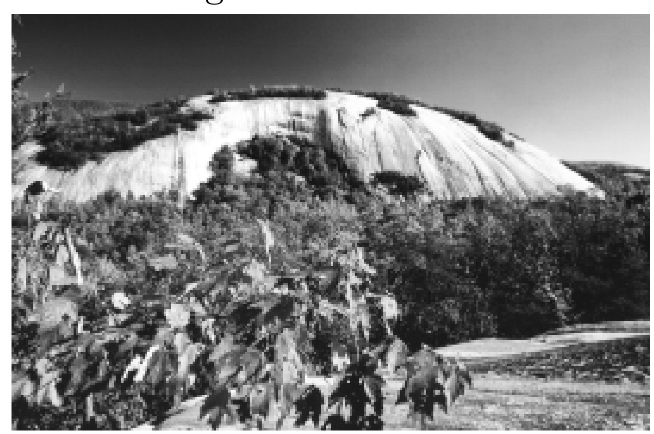
Stop A, continued

Examine other weathering features, such as the patterns of black, green and gray stains on the rock. What do you think caused them? Can you find places where sheets of rock look like they are peeling off the surface of the pavement?

Exfoliation sheets are a distinctive weathering feature of granodiorite. As the overlying rock is slowly weathered away, pressure is released. This causes the rock below to expand slightly upward and outward. Cracks form parallel to the earth's surface and sheets of rock break off and erode away. The rock resembles a peeling onion!

STOP B - View of Stone Mountain

LOOK FOR: View the *exfoliation dome* of Stone Mountain through the forest on your left, before you turn left onto the Stone Mountain Connector Trail. How did this dome form? **NOTE:** This stop is visible only in late fall and winter when foliage is off the trees.



Stop C - Parallel Sheet Joint

LOOK FOR: On left side of trail, a large hemlock tree growing on top of a granodiorite outcrop.

Caution: Rock surface may be slippery! Watch out for snakes – do not put your hands in cracks.

Examine the cracks or **joints** in the granodiorite. Notice that some of the cracks are parallel to the surface of the rock. These cracks are called **parallel sheet joints**. The sheets of rock between these joints are exfoliation sheets, like those at Stop A.

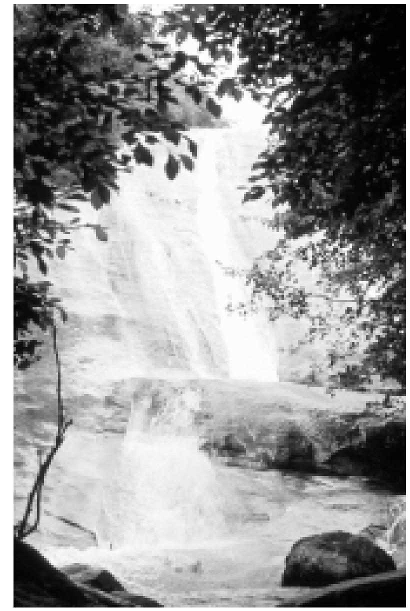
You should also be able to see **vertical fractures** in the rock. These formed when, at some point, the slab of rock moved forward. See how the rock is leaning forward toward us.

Notice also how the quartz is standing above the other minerals, creating a very irregular surface. This results from **differential weathering** – the quartz is more resistant to weathering than the biotite or feldspar in the granodiorite.

How are the trees and other plants interacting with the rock? Can they contribute to weathering?

Stop H - Stone Mountain Falls From Platform

LOOK FOR: Viewing platform halfway down falls.



As you descend the stairs to the viewing platform, notice the slabs of rocks to the left of the trail. These rocks probably slid down the slope along exfoliation planes. The mass of rocks at the bottom of a slope or cliff is called a **colluvial deposit**.

Observe the falls from the viewing platform. Stone Mountain Falls descends more than 200 feet down a steep rock face and into a shallow pool below. Geologists say it is technically more accurate to call Stone Mountain Falls a **cascade**. A true waterfall has free-falling water *not* in contact with the rock. Cascades typically have water in contact with rock.

Stop G - Nature's Steps

LOOK FOR: Feature in the rock that looks like stair steps.

Notice the unusual pattern in the rock here. It looks like stair steps, doesn't it? Why do you think the rock weathered this way?

Geologists describe this feature as a **dike**. A dike is an igneous intrusion that cuts across the bedding or **foliation** of the surrounding rock. Cross-cutting features such as this dike are always younger than the rock they have intruded.

In this case, the intrusion looks quite similar to the surrounding granodiorite, but is of a slightly different composition. The dike is standing out above the surrounding rock; therefore, it is more erosion-resistant than the surrounding rock. Perhaps it contains more quartz? Examine the dike rock with a hand lens. Compare it to the surrounding rock.

Notice also the vertical joint running alongside the dike. Could there be a relationship between these two features?

Stop D - Bridge Over Big Sandy Creek

LOOK FOR: Bridge over stream.

The headwaters for Big Sandy Creek are located northeast about 1.75 miles from here. From this point, the creek continues southwest for another two miles where it flows into the East Prong of the Roaring River.

Water is a significant cause of weathering and erosion. Compare the rocks you find in the creek with the rocks you have seen at Stops A and C. Are they the same kind of rocks? If not, where did they come from?

Notice how the water is cutting away the soil on the outside of the bend in the stream and depositing sediment on the inside of the streambed. The sediment on the inside is called a **point bar**. The photo below shows how the creek looked *before* the park staff left a buffer of uncut vegetation along the shoreline. What does this area look like today?

Stop E - Chimney of Native Stone

LOOK FOR: Chimney at the top of the hill on the trail.

One way that humans use rocks to their advantage is for building stones. This chimney was made from granodiorite found in the park. It was part of a cabin likely built in the 1800s. Why do you think the builder chose this location for a home?

Explore the area around the old homesite and imagine what it might have been like to live here before the park was established.

Use a hand lens to examine the feldspar, quartz and biotite (mica) minerals in the stones. How did the chimney maker "glue" the stones together?

Think about how you use rocks and minerals in your daily life. Were rocks and minerals used to build your home? Consider the Sheetrock walls, concrete foundation and aluminum window frames and/or siding. And what about the glass in your windows?

Stop F - Top of Falls

LOOK FOR: Fenced area at top of falls.

<u>Caution:</u> The fence is there for your protection. Stay behind it and away from the water!

You are now at the top of Stone Mountain Falls, very near the **knickpoint**. A knickpoint is an erosional feature marked by a change in the **gradient** of the stream. From this point the gradient, or rise over run, increases drastically.

From your observation point on the "safe side" of the fence, observe how the stream water flows over the rock. In some places it swirls around. Can you see any features in the rock that may affect the water flow?

Also, compare the rock surface you are standing on with the rock surface on the other side of the fence. What accounts for the differences?

Post-Visit Activity #1 Minerals in Our Lives

Major Concepts:
- Uses of rocks and minerals
- Nonrenewable resources
- Availability of resources

Learning Skills:
- Communicating, observing and classifying
- Analyzing information
- Writing a journal entry and constructing a glossary

Subject Areas:
- Science
- English Language Arts
- Social Studies

* See Activity Summary for a Correlation with DPI objectives in these subject areas.

Location: Classroom

Group Size: 25 or less

Estimated Time:
30-45 minutes

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: One copy of Minerals in Our Lives Story and associated Glossary, paper and pencil

Credits: Adapted from the "The Importance of Industrial Minerals in Our Everyday Lives" written by Hal McVey and revised by Bill Durbine, Nevada Division of Minerals, June 1998.

Objectives:

- Identify everyday items that come from rocks and minerals.
- Complete a journal entry of a typical day noting the many products used that come from rocks and minerals.
- Describe how life would be changed without products derived from rocks and minerals.
- Explain the impact of a growing world population on the earth's mineral resources.
- Describe at least three ways each of us can conserve mineral resources.

Educator's Information:

Few people realize the important role **minerals** play in our everday lives. In this activity, the students will read, or listen to a story about a typical family getting ready for school and work. The students will count the number of times products that come from **rocks** and minerals are mentioned in the story. Later, they will write about their own typical day and identify the products they use that come from rocks and minerals. Students will have an opportunity to discuss the impacts of a growing world population on our nonrenewable resources such as rocks and minerals.

Instructions:

1. Give each student a photocopy of the Minerals in Our Lives Story. Ask the students to circle the names of products and other items that they think might come from rocks and minerals. Note: For younger students, the teacher may prefer to read the story out loud. If the students are listening to the story, they should make a mark on a piece of paper whenever they hear something that could have come from rocks and minerals.

2. Ask each student to write on the board or overhead the number of items he/she found in the story that could have come from rocks and minerals. Calculate a class average.

3. Pass out the Glossary for Minerals in Our Lives Story. All the words in the glossary are items from the story that are derived from rocks and minerals. There are 73 words in the glossary. How does this number compare with the number of products that each student counted? Using the glossary, have students listen to or read the story again. Circle or mark all the items that come from rocks and minerals. Note: The glossary is not an exhaustive list. Students may find additional items to place in the glossary.

4. Ask students to write a journal entry that describes a typical day in each of their lives. They can use a story format such as the Minerals in Our Lives Story, or simply list their daily activities by time. (Example: 7 AM - wake up; 7:15 - take shower; 7:30 - eat breakfast; 8:00 - ride school bus to school, etc.) After they write their journal entry, they should create a glossary that shows how they use rocks and minerals in their typical day. They should include at least five words from their story in their glossary. For example, an entry for *breakfast* might say, " cereal is grown with fertilizers from minerals and the cereal bowl is made from minerals such as quartz (silica) and feldspar."

5. Discuss as a class:

• What are some of the ways we all use rocks and minerals in our daily lives?

• How would your life change if you did not have access to a mineral such as oil? Where does most of our energy come from to power cars, machines, electric generators, etc.? (fossil fuels) How do you think our society would be changed if we did not have ready and economical access to rocks and minerals?

• Rocks and minerals are nonrenewable (finite) resources. The human population on our planet is growing; more and more people require products that use rocks and minerals. How can we make sure that future generations will have access to the rocks and minerals we use today? What are some ways to make our rock and mineral resources last longer? (Hint: Reduce, reuse, recycle) Are some mineral resources less available (more scarce) than others? Do some countries have more mineral resources than others?

Assessment:

Pencil and paper quiz:

• Ask students to write down things they use every day that come from rocks and minerals. For each item listed, they should describe the specific rocks and minerals that may contribute to it.

• Ask students to describe how their life would be changed if all the products derived from rocks and minerals were removed.

• Finally ask students to explain why it is important to conserve rock and mineral resources, and describe three ways this might be done.

For younger students:

• Ask them to create and illustrate a web diagram of their day and the minerals they consumed that day.

• Ask students to work in teams or small groups to create and label a collage of pictures from magazines that show our society's daily consumption of minerals. Each group should also illustrate ways that each of us can conserve rock and mineral resources.

Extension:

• Have students look up some of the rocks and minerals mentioned in the glossary. Where and how are these materials mined? How many are mined in North Carolina? in other states? in other countries?

• Assign a specific item for each student to research. What can they find out about the ingredients and manufacture of this item? Are there any rock and mineral resources in other countries on which our society depends for the manufacture of this item?

Minerals in Our Lives Story

As the Johnsons step out of bed in the morning, they place their feet on the carpet and make their way to the kitchen, one at a time. Sara Johnson is usually the first one up. She flips on an electric light and puts on her eyeglasses. In the kitchen, she begins brewing coffee in the coffee maker. Her son Jason is the next one up. He slides across the kitchen linoleum in his socks and looks for his favorite cereal box on the kitchen counter. Oh no, dad's been playing handyman again.

Last night Brad Johnson decided to install some ceramic tile on the counter top. His tools, along with jars of putty and caulking compound are all over the place. Sara pushes the tools aside and helps Jason locate his cereal and a ceramic bowl. Soon Jason is happily slurping up "Tasty Oats – The Breakfast of Winners" with a metal spoon.

Brad wanders in sleepily, pours some coffee into a large glass mug and sits down to read the newspaper. Sara decides its time to plan a family vacation. She consults her Official Airline Guide and then refers to the Yellow Pages of the phone book for the number of the airline.

While Sara fixes herself a piece of toast to go with her coffee, Jason sneaks a piece of cake from last night's party. Next, Jason packs his lunch and Sara considers what to prepare for the evening meal.

They all finish breakfast and begin getting ready for work and school. In the process, they brush their teeth with toothpaste. Sara applies some lipstick and makeup, while Brad puts some styling cream on his curly hair.

In their bathroom, Brad has installed a counter top of synthetic marble and a shower stall made of fiberglass. Sara keeps some cleaner under the bathroom sink and reminds everyone to use it to keep the bathroom shiny and clean.

As Sara finishes dressing, she decides to brighten up her outfit with some jewelry. Brad puts on his new quartz watch. Jason puts some coins in his pocket for the drink machine at school.

Before they leave the house, Sara takes a few minutes to straighten up some items in disarray on the what-not shelf. Apparently, Buster the cat climbed on the shelf again last night and knocked over one of the porcelain figurines.

Speaking of Buster, there is one last unattractive task for Jason to do before he leaves for school – change the cat litter in Buster's litter box.

As soon as he's finished, Jason puts on his helmet, grabs his lunch and heads for school on his new mountain bike. Sara and Brad walk out together. Brad makes a mental note that he needs to have the fiberglass shingles on the house replaced. Sara sees some bare spots in the flower bed in front of the house. Has Buster been digging there again? She'll have to stop at the nursery on the way home and pick up some planting mix and fertilizer along with a few new bedding plants.

Sara climbs into the driver's seat of the family van, but not before Brad notices one of the tires is a little low. He'll add some more air later. He still can't believe Sara agreed to let him buy some cool mag wheels for the van!

It's a nice day, so Brad rolls down the tinted window and places his travel mug in the plastic cup holder. The paint job the van received after his little fender bender last month looks pretty sharp.

The road they drive on to work is concrete pavement composed of cement and aggregate. Sara pulls the van into the asphalt parking lot at Brad's workplace, Computer Systems. She drops Brad off and continues her trip to a large steel-framed skyscraper downtown.

Meanwhile Jason has made it to school and is staring at the Sheetrock walls in first period. What a boring class! He taps his foot on the floor until the bell rings and it's time to go to the next class. He makes a quick stop in the restroom.

Up in the skyscraper downtown, Sara begins her work as a receptionist for a large law firm. She answers the telephone all day. Between calls, she uses a pencil to make a list of things to do. One of the first items on her list is to send out a few invoices, which are backed with self-contained carbon paper. There are also some items to be ordered for the office. She picks up a catalog, begins leafing through it and notices the slick feel of the fine glossy paper.

Meanwhile at Computer Systems, Brad is busy at his computer designing new software. The morning has passed quickly and it's time for a break. He adds a packet of sugar to his third cup of coffee and decides to heat up a cinnamon roll, which he places in a microwave-safe container. While on break, Brad's thoughts rove toward the weekend ahead and the recreational activities he'd like to pursue. These include golfing, playing tennis, fishing and water skiing.

Then Brad remembers that his son Jason said something about a camping trip the other day. Wasn't Jason looking in the garage last night for his aluminum-frame backpack and pots and pans? He'll probably need the old gas lantern, too.

It seems like Sara said she might head for the community swimming pool for a few hours of splashing around. That will leave plenty of time to go golfing with the guys. Quit daydreaming Brad, it's back to work for you!

After a hard day at the office and school, the family arrives back home. Jason helps set the table and makes sure there is plenty of salt. (He likes salt on everything.) Everyone drinks lots of water with the meal because it's a spicy Mexican dish. Sara notices she put too much vegetable oil in the salad dressing. The lettuce tastes a little slimy. Brad chews on a few antacid tablets while Sara resorts to Milk of Magnesia. Jason's preferred cure is Kaopectate for relief of his upset stomach. His mom likes to experiment with new foods, but this meal's a loser!

After dinner, Brad and Sara spend a few moments relaxing in the backyard where they admire their landscaping efforts. Sara notices that the plaster of Paris birdbath on the back lawn is getting many visitors.

Jason does some homework, takes in a little television and gets ready for bed. They all turn in early so they'll be ready for the big weekend ahead.

Glossary for Minerals in Our Lives Story

Aggregate: pieces of rocks such as limestone, dolomite, granite, lava rocks, etc.

Aluminum-frame backpack: the element aluminum comes from the mineral bauxite, which is one of the most widely-utilized minerals.

Antacid tablet: contains calcium carbonate, perhaps from limestone.

Asphalt parking lot: comes from oil and may also be mixed with talc, silica sand, limestone and other aggregates.

Cake: contains minerals such as gypsum, especially in the icing.

Carbon paper: contains bentonite or other clays and zeolites.

Carpet: calcium carbonate (limestone) is used in carpet backing; many carpets are made from oil-based materials.

Cat litter: may be composed of variations of pumice, volcanic ash and zeolite.

Catalog: various kinds of paper are filled with, or use the following materials in their processing – limestone, sodium sulfate and soda ash.

Caulking compound: contains limestone and gypsum.

Cement: manufactured from limestone, gypsum, iron oxides, clays and possibly pozzuolana (volcanic ash).

Ceramic bowl: may contain the following – silica sand, limestone, talc, lithium, borates, soda ash and feldspar.

Ceramic tile: made from silica sand, limestone and clays.

Cereal: the wheat or other grains in the cereal were grown with fertilizers (derived from minerals) and were harvested and brought to market with machinery made of minerals and powered by oil (mineral). Elements such as iron and calcium may be added to fortify the cereal to make it healthier for you to eat.

Cleanser: may contain materials like silica, pumice, feldspar and limestone.

Coffee maker: the pot is probably made of glass (from silica sand) and the base is probably made of plastics (from oil).

Coins: various metals (from ores of copper, nickel, zinc, etc.) are used to make coins.

Computer: the computer chips are made of silicon; the screen is made of silicon, boron, lead, indium, strontium, barium and phosphorous; the case is made of calcium carbonate, talc, clays, sulfur, mica and plastics (from oil); the circuitry is made of gold, copper, aluminum, steel, lithium, tungsten, silver, cobalt, nickel, germanium, tin, lead and zinc.

Concrete pavement: see Cement and Aggregates.

Electric light: silica sand, limestone, tungsten and copper.

Eyeglasses: made from soda ash, limestone and feldspar.

Fertilizer: composed of potash, phosphates, nitrates, borates, sulfur and other minerals.

<u>**Glossary, page 2**</u>

Fiberglass: made of silica sand, colemanite, limestone, feldspar and soda ash.

Fishing: the fishing rod may be made of graphite; older rods may be made of fiberglass.

Floor: floor or deck between floors may be made of perlite, vermiculite, zeolite or expanded shale; floor tiles may be made of limestone, pyrophyllite and talc.

Gas lantern: the lantern mantle is made of thorium; see also Glass (below).

Glass mug: glass is made from silica sand and may also include limestone, talc, lithium, borates, soda ash and feldspar.

Glossy paper: the slick feeling of this paper is due to a high content of kaolin clay or calcium carbonate along with titanium dioxide for extreme whiteness.

Golfing: golf clubs are made from graphite; minerals are used to keep the course green.

Helmet: calcium carbonate, talc, clays, sulfur, mica and plastics (from oil).

Jewelry: all precious or semi-precious stones are minerals; for example, opal, amethyst, aquamarine, topaz, garnet and diamond.

Kaopectate: comes from kaolin.

Lettuce: is grown using fertilizers. See Fertilizer.

Linoleum: contains calcium carbonate, clay and wollastonite.

Lipstick: may contain talc, calcium carbonate, clay and mica.

Mag wheels: are made from steel or aluminum alloys that contain dolomite and magnesium.

Makeup: see Lipstick.

Metal spoon: some spoons contain silver. See also entries for Aluminum or Steel.

Microwave-safe container: plastic (from oil) filled or reinforced with talc, calcium carbonate, titanium dioxide or clays.

Milk of Magnesia: made from dolomite/magnesia.

Mountain bike: the frame may be made of steel, aluminum, titanium and/or carbon fiber; the handlebars are made of aluminum and titanium; the brakes are made of aluminum, steel and magnesium; the tires are made of sulfur, bromine and iodine; the cabling is made of steel.

Newspaper: see Catalog for information on the minerals in paper.

Official Airline Guide: see Catalog.

Paint: is composed in large part of minerals such as kaolin clays, calcium carbonate, micas, talc, silca, wollastonite and titanium dioxide.

Pencil: the lead is made of graphite and clays.

Planting mix: probably includes vermiculite, perlite, gypsum, zeolites and peat.

Plaster of Paris birdbath: made from gypsum.

Glossary, page 3

Plastic cup holder: plastics come from oil and require the following for their manufacture – calcium carbonate, wollastonite, mica, talc, clays and silica.

Porcelain figurine: made of silica, limestone, borates and soda ash.

Pots and pans: could be made of aluminum (lightweight for backpacking) or steel.

Putty: contains limestone and gypsum.

Quartz watch: the quartz crystal in the watch conducts electricity.

Restroom: the wastewater from the restroom facility is handled by a wastewater treatment plant, which uses a wide variety of minerals such as zeolites, soda ash, lime and salt.

Salt: is the mineral halite.

Sheetrock walls: made of gypsum and include fire retardant additives such as clay, perlite, vermiculite, alumina hydrate and borates.

Shingles: see entries for Fiberglass and Asphalt.

Steel-framed skyscraper: in addition to iron and carbon, steel may contain other metals. Earth resources used in its manufacture include fluorospar, bentonite, chromite, bauxite, zircon, silica, graphite, hyanite, andulusite, sillimanite and clays.

Styling cream: may contain calcium carbonate.

Sugar: calcium carbonate (limestone) is used in sugar refining.

Swimming pool: the clarity and purity of the water is maintained by the use of a filtering system made from diatomite, perlite and clays.

Synthetic marble: made of titanium dioxide, calcium carbonate and alumina.

Teeth: your teeth and bones contain calcium.

Telephone: optical fibers made from glass (silica) are now replacing copper wires. See also Computer to get an idea of other minerals used in telephones.

Television: see entry for Computer.

Tennis: tennis rackets can be made of graphite.

Tinted window: may contain fluorospar in addition to glass (silica).

Tires: contain clays, calcium carbonate, sulfur and barite.

Toast: bread and bakery items contain gypsum.

Tools: probably made of steel. See entry for Steel-framed skyscraper.

Toothpaste: may contain calcium carbonate, silica, sodium carbonate and fluorite.

Vegetable oil: is made clear through use of mineral filters including clay, diatomite or perlite.

Water skiing: the skis are probably made of graphite.

Yellow Pages: see Catalog entry for information about paper.

Post-Visit Activity #2 — Do You Mine?

Major Concepts:
- Mining
- Environmental issues
- Conservation of natural resources

Learning Skills:
- Predicting, communicating
- Participating effectively in groups, problem solving
- Using language for personal response
- Evaluating the accuracy and value of information and ideas

Subject Areas:
- Science
- English Language Arts
- Social Studies

* See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

Location: Classroom

Group Size: 30 students

Estimated Time: 90 minutes (two 45-minute periods over a two or three day period would be preferable)

Appropriate Season: Any

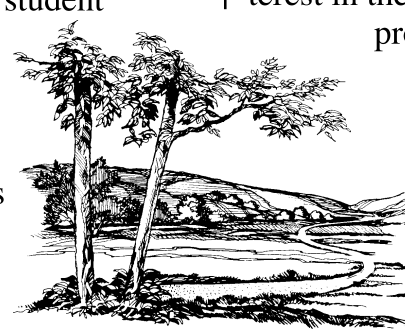
Materials:
Provided by educator:
Per student: One copy of Student's Information with maps, and a Possible Arguments page that either supports or opposes the mining project (pp. 5.3.6 - 5.3.7)
Per class: Additional resources on mining – Call N.C. Land Quality Section at (919) 733-4574.

Objectives:

- Write an essay supporting or opposing a proposed mining operation near a state park. Provide at least three logical reasons to support the position.
- Listen critically to oral presentations and write notes of key points.
- Demonstrate a willingness to acknowledge other points of view and work toward a group solution to a natural resource issue.

Educator's Information:

In this activity, students will explore many viewpoints surrounding mining adjacent to a state park. A realistic scenario is provided that centers on an imaginary state park in a fictitious county. Each student should choose or be assigned a viewpoint to represent. The purpose of this activity is to help students become aware of environmental issues related to earth resources, appreciate different points of view, and develop skills in problem solving.



The process for citizen participation in the mining issue presented in this activity roughly parallels the process followed in North Carolina. The North Carolina Department of Environment and Natural Resources (DENR) receives and reviews applications from individuals and companies that would like to conduct mining activities here. (The actual agency within DENR that is responsible for this review is the Land Quality Section of the Division of Land Resources.) The applicant must notify adjacent landowners, local government officials, and other interested parties that he/she has filed a mining permit application with DENR. All parties have 30 days to prepare written comments and request a public hearing in the application.

Depending on public interest in the proposed project and the potential environmental impacts, DENR may schedule and conduct a public hearing. At the hearing, private citizens and groups may present their views and learn more about the proposed mining project. DENR staff evaluates the technical issues concerning the project as well as the public comments provided, then makes a recommendation to the Director of DENR's Division of Land Resources. The Director ultimately makes the final decision on the application. If mining is allowed, the company is given a permit that details the procedures and precautions it must follow to minimize environmental impacts from the project.

Instructions:

1. Give each student a copy of the Student's Information and discuss the proposed mining project near White Dome State Park. List pros and cons of the mining project on the chalkboard or overhead. Also, list all possible stakeholders in this issue.

2. Divide the class in half; give one half the opposing viewpoints, and the other half the supporting viewpoints. Assign, or ask them to choose a viewpoint from their sheet and write an essay explaining this position. This could also be done in the form of a letter to the State Mining Board. Each student should have at least three key points to back up their argument. If desired, give students time to research their viewpoint, their interest group, or more about mining operations in general.

3. Ask several students on each side of the debate to read their essays or letters to the class. The students should make notes of the key points presented. Then, as a class or in small groups, brainstorm solutions to the problem; the goal should be to list as many solutions as possible. Next, have students suggest criteria that could be used to evaluate the solutions. Finally, use the criteria to rank the solutions. If this is done in small groups, ask each group to report on its top-ranked solution. Discuss ways that environmental issues are resolved in a democratic society.

4. Be sure to explain to students the actual process in North Carolina in which citizens can learn about mining projects in their area and present their opinions. (See the Educator's Information in this activity.) Contact the Land Quality Section for more information or visit their website at http://www.dlr.enr.state.nc.us

Find out how citizens of other countries might solve a similar resource issue. Which governmental agencies would they contact for assistance?

Assessment:

Have each student write a second essay representing a different viewpoint. For example, if the student's first essay was opposed to the mining project, her second essay should be in support of the project.

Modification:

Do this activity as a simulated public hearing where student teams are assigned interest groups to represent at the hearing. Each team could orally present its position to a group of students role playing the State Mining Board. After listening to all the interest groups, the State Mining Board should make a recommendation, explaining their reasons to the class.

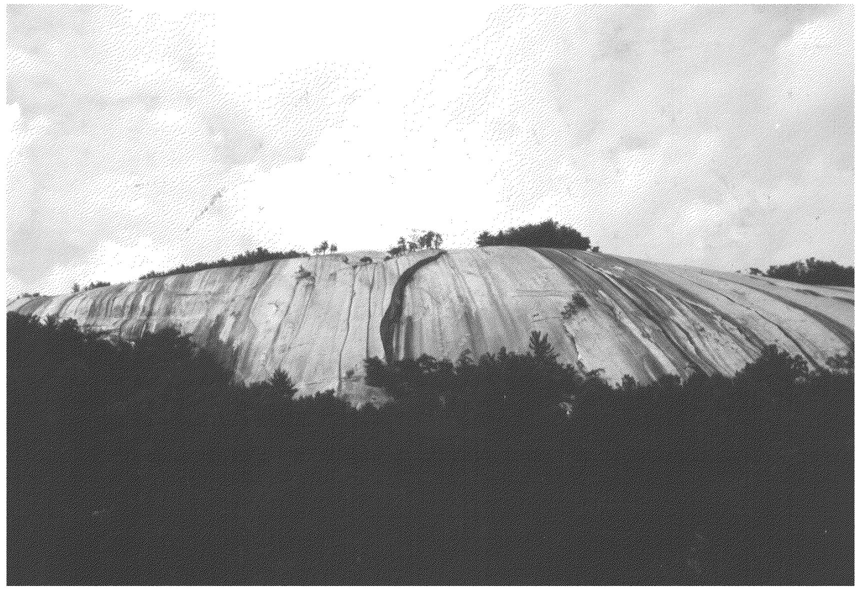
Extension:

Have students do research on a real environmental issue in their state or county. Identify all the interest groups and their positions. Who made the final decision on how the issue was to be resolved? What agency or group of people carried out the solution? What was the outcome?

Student's Information "Do You Mine?"

White Dome State Park consists of 900 acres in the heart of the Sentinel Mountains. The Sentinel Mountains are an ancient mountain range with beautiful rock formations and waterfalls. Located in Granite County, the park is only a two to three hour drive from several large metropolitan areas. It is one of the most popular places in the state for hiking, picnicking and relaxing. Several rare and endangered species reside in the park and are part of an ongoing research study by a local university.

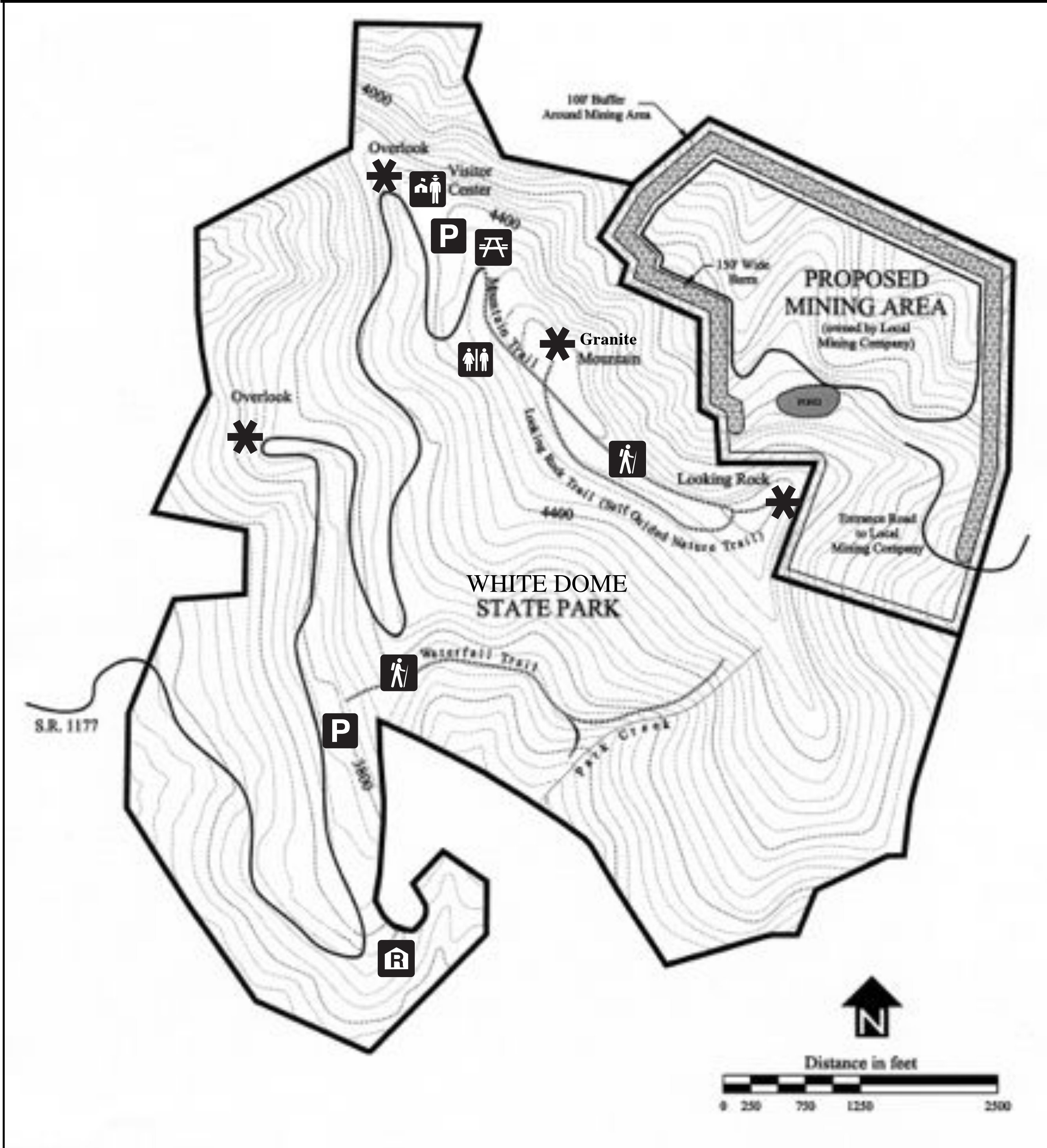
The park protects an exposed **pluton** of **granodiorite** rock that is a popular rock climbing area. To ensure that the entire pluton is preserved, the State Parks Department would like to add another 600 acres of land adjacent to the existing White Dome State Park. Park visitation and demands for recreational services have increased greatly over the past ten years. To meet these demands, the State Parks Department would like to put a family campground at the base of the ridge line on this proposed addition to the park. The Department also has plans to connect the existing trail system with this campground, to add a mountain bike trail, and provide for horseback riding.



A local mining company owns this 600-acre parcel and would like to mine the valuable granodiorite rock for use as building stone. This company has applied for a permit from the State Mining Board to proceed with their mining operation. The mining company estimates it will take them 40-50 years to remove all the stone. They have found a potential market for their stone. A real estate development company has purchased a large area of land near White Dome State Park with the intention of building an industrial park. This development company would like to use local stone in the construction of their office buildings.

The State Mining Board has set up a hearing to listen to all sides of the issue. They will decide whether the mining company should be allowed to mine so close to a state park. If they allow the mining activity, they will outline, in a permit, what types of mining activities are allowed or not allowed. If they decide against the mining activity, they may help determine a fair price for the land – if the State Legislature should agree to purchase the 600 acres and increase the size of White Dome State Park.

Student's Information Park Map

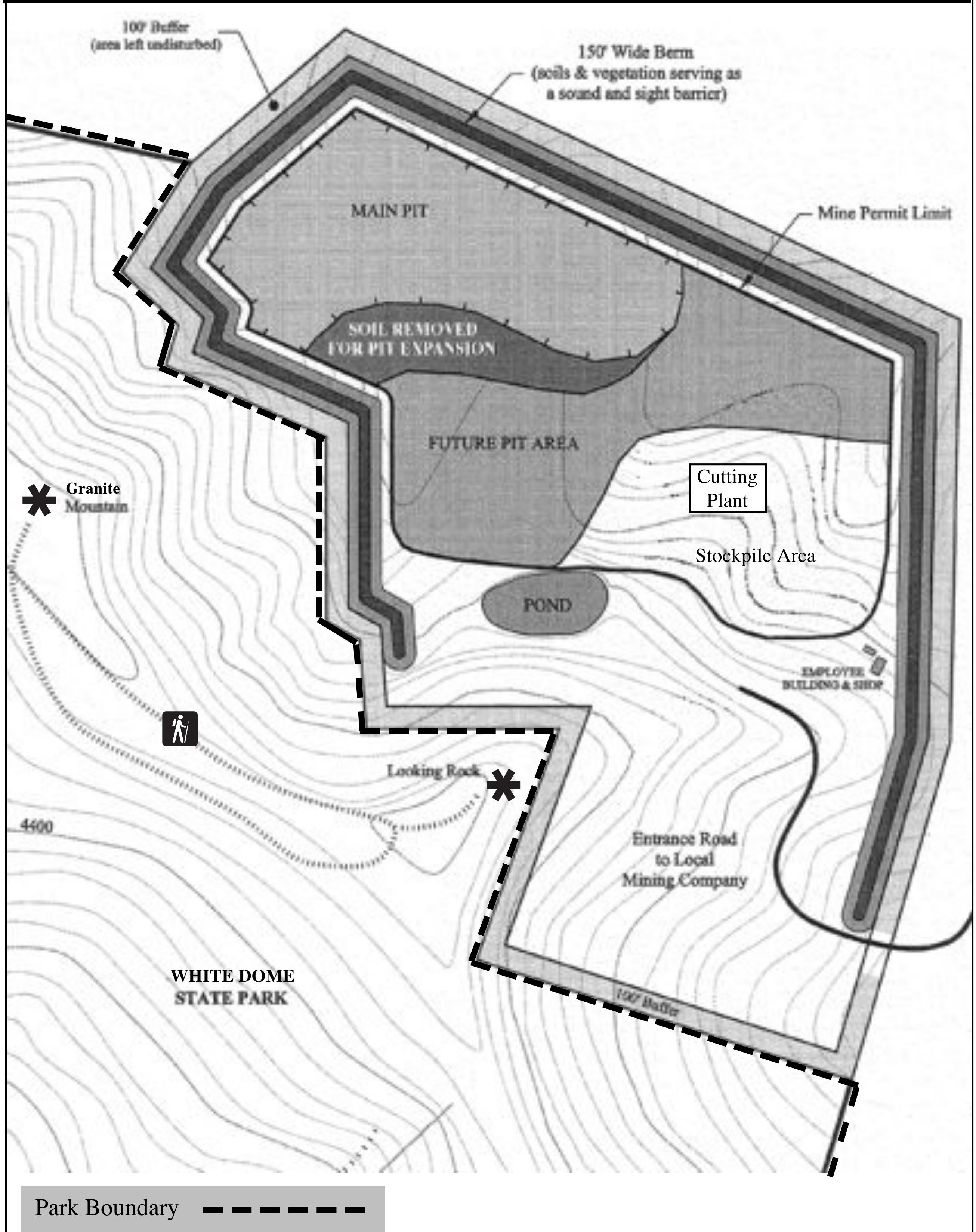


Map Provided by Martin Marietta Aggregates, Raleigh, NC.

Legend

Hiking Trail
Picnicking
Restrooms
Visitor Center
Parking Area
Point of Interest
Ranger Residence

Student's Information Quarry Map



Map Provided by Martin Marietta Aggregates, Raleigh, NC

Possible Arguments for <u>Supporting</u> the Mining Project

Local Mining Company

If you are allowed to mine the granodiorite in Granite County, you could hire more employees and thus lower unemployment in the county. Also, the more money your company makes, the more taxes they pay. This would surely help the local economy. You will take every reasonable measure to protect the environment, as required by law. However, there will be some effects. You will have to fracture the rock either by cutting it with diamond saws or blasting it with small explosives. The rock will then be cut into smaller blocks and transported with heavy equipment. You plan to leave a 100-foot buffer area around the mining pit and provide a sight and sound barrier as well.

You have read the park's master plan. You know that the state would like to add at least another 600 acres to increase the size of the park. How much more land in Granite County is the state going to take out of the tax base and make off limits to your mining company? You would be willing to sell your land to the state very cheaply after you remove the building stone in about 40 years. At that time, you will do your best to restore the area so that it can be used as a campground, ball field, or other recreation area.

Real Estate Development Company

You are eager to work with the local mining company and local businesses in the construction of a new industrial park in Granite County. Using local materials in building construction will increase your profits and lower building costs – because the cost of transporting materials to the building site will be reduced. Furthermore, you think it is possible to minimize the impacts of mining and development. In your opinion, the loss of a few species of plants or animals is a small price to pay for progress and an increase in the number of jobs in the county. Since you use the most advanced energy conservation techniques in the design of your office buildings, your industrial park will help the environment in the long run. Finally, the taxes on the sale of your buildings will bring enough money into the county to build a new library and modern schools, which are very much needed in this rural area.

Chamber of Commerce

You support this project, with some reservations. Your mission is to bring business and industry to Granite County to create new jobs and provide the county with extra tax money. A new industrial park should attract new businesses to the area, create many new jobs, and help your rural economy to grow. You are concerned that some of the jobs would be temporary – just during mining and construction. However, if more schools and a library were built with the tax money, then there would be more jobs for teachers, librarians and others. All the new development would mean more money in property taxes. You are a little worried about the project's effect on the state park. Some of the income in the county comes from tourists visiting the park. A mining operation near a state park might discourage tourists. Some local businesses might suffer.

Local Association of General Contractors

You support this project because it will mean more work for you. You are happy to hear that stone is becoming popular in the construction of new office buildings. The quality of the local stone is excellent and you would prefer to work with it. However, you are willing to work with <u>any</u> kind of stone. You worry that if the local mining project is not allowed, it may be too expensive for the real estate company to transport stone from other parts of the United States. The real estate company may decide to abandon the industrial park project altogether. This would be a serious economic loss to the local contractors!

Possible Arguments for Opposing the Mining Project

State Parks Department

Your mission is to protect and preserve the natural environment, and provide recreational opportunities to the public. Park visitors often request camping facilities. The proposed addition to White Dome State Park would be an excellent place for a family campground. This area is home to several rare and endangered plant species. A mining operation would destroy plant communities and valuable wildlife habitat. Trees would be removed, the ground would be bulldozed, and the resulting erosion and sedimentation might damage water quality in the pond, if not properly controlled. You are also concerned about visitor safety in and around a mining operation. Ensuring that park visitors do not wander off the park and into the proposed mining area would add to the park rangers' duties. Also, what happens when the mining operation ends? Old rock quarries fill up with water and can be dangerous places. In your opinion, after mining, this area would not be a safe place for a campground.

A Hiking or Wilderness Club

You are a large group of citizens including anglers, rock climbers, hikers, bird watchers and campers. You would like to see more land officially become part of the state park. You are also in favor of the proposed campground as it would provide a central location for camping. This would protect the wilderness by reducing the impact of many smaller campsites or picnic areas spread over the whole park. The park is one of the few undeveloped places in the area where people can go to "get away from it all" and enjoy a truly wilderness experience. A mining operation would destroy the breathtaking scenic views as well as the beautiful and rare plant communities. If not properly controlled, the erosion and sedimentation resulting from the mining operation could damage water quality and kill fish. Also, the noise from the trucks and the rock cutting and blasting is offensive to those people who come to the area for peace and quiet. Preserving the environment is more important than increasing tax revenues.

Local Residents

You are a group of Granite County residents who live near the proposed mining operation. You believe this operation will lower your property values. You do not want to hear rock cutting and blasting, or to have heavy truck traffic in your neighborhood. When the mining operation is over, you are concerned that the abandoned quarry will become a dangerous place. You want to know what kind of land reclamation the mining company plans to do after mining is over. You are also worried about the new industrial park. What kinds of businesses and industries will operate in this park? Will they pollute your air and water? You hope that if the mining project is not allowed, the real estate company will drop its plans to build the industrial park. You moved to Granite County to be closer to nature and to get away from crowds and traffic. You'd much rather see the land, now owned by the mining company, become part of White Dome State Park.

Local Ecotourism Businesses

You own one of the small businesses that cater to tourists who come to the state park to go fishing, hiking, camping, rock climbing, mountain biking, and horseback riding. Ecotourism businesses include restaurants, gas stations, and sporting goods stores that sell or rent outdoor recreational equipment to the tourists. You are opposed to the mining operation as you feel it would negatively impact your business by scaring away the tourists. You believe that the proposed family campground would increase your business by providing more recreational opportunities. You are in favor of anything that would increase park visitation.

Post-Visit Activity #3 — Mining in a Nutshell

Major Concepts:
- Phases of mining operations
- Raw material consumption
- Reclamation

Learning Skills:
- Observing, classifying, inferring
- Noting important details and drawing conclusions
- Gathering and organizing information
- Mapping

Subject Areas:
- Science
- English Language Arts
- Social Studies

* See Activity Summary for a Correlation with DPI objectives in these subject areas.

Location: Classroom and home

Group Size: 30 or less

Estimated Time: Part I — 30 to 45 minutes; Part II — 45 minutes

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: Student's Information, sheet of graph paper for map making, pen or pencil
Per class: 2-3 pounds of roasted peanuts in the shell, assorted colors of enamel paint (or fingernail polish) and brushes, blender, vegetable oil, honey, and salt (optional), celery sticks, crackers, apple slices, plastic knives, rock and mineral samples and associated products.
Optional: "From the Mine to My Home" poster - available from the National Energy Foundation at (800) 616-8326. Order item #40MMH.

Credits: Adapted from the "Mining In A Nutshell" activity by Walt Lombardo of the Nevada Division of Minerals. Found in the *Minerals Education Curriculum Notebook* by the Interstate Mining Compact Commission. Student's Information on reclamation is excerpted from the Interstate Mining Compact Commission Reclamation Poster.

Objectives:
- List and describe at least five phases in mining earth resources from the initial discovery of a mineral deposit through society's consumption of a finished mineral product.
- Explain at least three ways that mining companies can reduce environmental impacts.

Prerequisites:
We recommend that the students complete Pre-visit Activity #3, "Mineral Study," and/or Post-visit Activity #1, "Minerals in Our Lives," before doing this activity.

Educator's Information:
In this activity, students will participate in a mining simulation that uses shelled peanuts to represent mineral resources. In teams, students will experience the exploration, extraction, processing, manufacturing and consumption phases of mining. Then they will read about and discuss the permitting and reclamation phases.

Teachers can follow the teacher script provided, or use a learning cycle approach. If using the learning cycle, omit the teacher script and introduce the mining information after the simulation is completed. Consider applying the concepts to actual mining examples in North Carolina or elsewhere.

Safety Advisory

This activity involves the use of shelled peanuts. Before doing this activity, find out if any students are allergic to peanut products. If so, substitute chocolate candies wrapped in paper or foil of different colors for the peanuts.

Instructions:

1. Paint spots of color on the unshelled peanuts using enamel paint or fingernail polish. Use several colors, each of which can represent a different mineral. For example: Yellow = Gold, Blue = Silver, Green = Copper, Red = Iron, Black = Lead, White = Gypsum. For each color used, paint 25-30 peanuts. Note: If using chocolate candies wrapped in foil/ paper, make sure you have 25-30 of each color.

2. Prepare a map of the room or location where this activity will be done. It should show major features like doors, windows, desks, and tables, cabinets, etc. A simple drawing on 8 1/2 by 11-inch graph paper should be sufficient. Provide copies for all students.

<u>OR</u>

2a. Have the students prepare their own maps of the items and features in the classroom.

Provide graph paper for the map preparation. If you know the orientation of the room, place signs on the walls denoting north, south, east and west. Have the students orient their maps with north at the top of the paper.

3. If available, set out samples of various minerals and some of the products made from them.

4. Hide the peanuts in various locations around the room. You can group different colors together in the hiding places. (Several different minerals are often found together in nature.) Keep track of how many peanuts of each color are hidden.

5. If available, post a "From the Mine to My Home" poster in a prominent spot in the classroom.

6. Divide students into groups of four to six. Identify each group by a color, for example: the Red table, the Yellow table, ***<u>OR</u>*** have the students at each table give their group a colorful name like the Blue Quartz Mine or the Red Devil Mine. (The colors selected should be the same as the colors used on the peanuts.)

7. Have the students explore the room and locate the peanuts of their assigned color. Challenge them to find all 25 or 30 peanuts of their assigned color. They should take their maps with them and plot where the peanuts are located. ***Do not remove the peanuts at this time.*** Relate the peanuts to the rock and mineral samples. (The rocks may contain useful minerals just as the whole peanuts contain the useful nuts within their shells.) Explain to the students that by locating the hiding places, the students have completed the ***Exploration phase*** of mining.

Say the following:

"In real life, geologists use a variety of tools and instruments to help locate mineral resources. Airplanes and helicopters with photographic equipment are used by geologists. They also use magnetic and gravity-detecting equipment. This equipment gives information about the earth's subsurface. Geologists sometimes use pictures taken from satellites in their search for mineral resources."

Discuss the various exploration processes shown on the poster. These include searching, drilling, analyzing, evaluating, discovering and identifying.

8. Next, in three to five minutes, have the students find and remove only the peanuts of their assigned color and return with them to their group's table. Have each group count the number of peanuts they found and record that number. Explain to the group that this represents the ***Extraction phase*** of mining.

Say: "In real life, after the resources are located, they must be removed from the earth. This process is called extraction. People build surface or underground mines to extract mineral resources. To get oil, holes are drilled deep into the earth. Mining and drilling are two ways we extract and produce mineral resources." Have the groups share their extraction (or mining) success. Were they able to find all the peanuts of their assigned color? Discuss various mining processes shown on the poster. They include blasting, digging, removing, loading, hauling and developing.

9. Have the students shell their peanuts. The peanuts and shells should be kept in separate piles at each table. (Note: If using chocoloate candies, ask students to remove the candies from the wrappers.) Explain that shelling the peanuts represents one step of the ***Processing phase***.

Say: "Valuable minerals are in ordinary looking rock when they are taken from the earth. They are often hidden as tiny particles in the rock. The valuable minerals are removed from the rock and concentrated. This is called processing and can include crushing, grinding, screening, separating and milling."

10. Ask someone from each of the teams to bring the shelled peanuts over to the blender. Place all of the shelled peanuts, along with vegetable oil, honey, and salt (if desired) in the blender. Turn on the blender and blend until all the ingredients become peanut butter. (Note: If using chocolate candies, you can melt the candies in a pan on a hot plate, or in a bowl in the microwave to make chocolate syrup.) Explain that this step of the ***Processing phase*** is called refining.

Say: "Some minerals have to be smelted and refined before they can be made into useful products. For example, when oil is pumped from the earth, it is in crude form. The crude oil is sent to a refinery where it is processed into oils, solvents, fuels and petrochemicals."

11. Using plastic knives, have the students spread the peanut butter on celery, crackers, and apple slices. (Note: If using chocoloate syrup, students can dip apple slices or other items into the syrup and let them cool on wax paper.) Explain that this is the ***Manufacturing phase.***

Say: "After the mineral and energy resources are refined, these raw materials are made into products during the manufacturing phase. Their transformation into consumer products is almost limitless. Products ranging from fertilizers to plastics, or from bicycles to airplanes are made by people and machinery."

12. Allow the students to eat the above manufactured items. Explain that this is the ***Consumption phase.***

Say: "We learned in previous activities how much we depend on rocks and minerals. Our homes and schools and everything in them – *everything* we use today – either has to grow (plants, trees, etc.) or it has to be mined from the earth. And plants (trees for lumber, fruits, and vegetables) and animals couldn't grow without the minerals in the earth for nutrition. It is virtually impossible to farm, process food, and manufacture clothing items without tools and machinery made from mineral products."

13. Distribute copies of the "Every American Born..." graphic on page 5.3.8 or project it on the wall with an overhead projector.

Say: "According to the Mineral Information Institute, every American born will need 3 3/4 million pounds of minerals, metals, and fuels in a lifetime." Ask students to react to this statement. Review the information on page 5.3.9 that lists many products that come from North Carolina mines. You can also use the poster "From the Mine to My Home" to recap the activity.

14. Explain to the students that although this activity demonstrates many of the steps that are taken in the mining process, it leaves out two very important steps. Can they guess what has been left out? ***(Permitting phase*** and the ***Reclamation phase***) These phases are necessary to prevent serious environmental impacts such as erosion and sedimentation in our rivers and streams.

15. Pass out copies of the Student's Information to each student. Ask them to read the information and underline ways that mining companies can avoid major environmental damage. As a class, list and discuss some of these methods.

Assessment:

Ask your students the questions below. This may be done as a class discussion, or students can write their answers on paper.

1. List the five steps in the mining process we actually simulated in our classroom mining activity.

Answer:

- *Exploration phase*
- *Extraction phase*
- *Processing phase*
- *Manufacturing phase*
- *Consumption phase*

2. What are the two additional phases that you read about in the Student's Information and why are they important?

Answer:

- *Permitting phase*
- *Reclamation phase*

Both are important to prevent serious environmental damages from mining.

3. Describe at least three ways that mining companies prevent environmental damage while mining, or ways they repair a site after mining.

Answer:

Refer to Student's Information and your class list.

4. What agency in the Department of Environment and Natural Resources approves or denies mining applications?

Answer: *The Land Quality Section of the Division of Land Resources.*

5. How many pounds of minerals, metals, and fuels will every American consume in a lifetime?

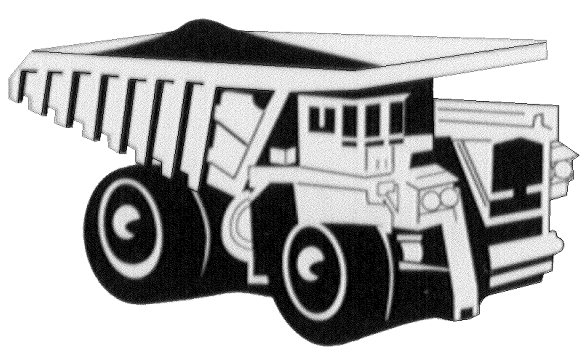
Answer: *3 3/4 million*

Extensions:

1. Visit a quarry or mine in your area.

2. Research the following:

- Are there additional phases in the mining process that weren't covered in this activity? (Hint: Marketing phase and Recycling phase)
- Why is recycling so important? (Hint: Mineral resources are nonrenewable. Research which ones are in short supply.)
- Which of the phases in a mining operation is likely to be the most expensive?



Student's Information:

The activity "Mining in a Nutshell" demonstrates many of the steps in the mining process. It leaves out two very important steps, however – the permitting phase and the reclamation phase.

Permitting Phase

A mining company must first submit an application to the North Carolina Department of Environment and Natural Resources (DENR) before it can perform any mining operation that will disturb one or more acres of land in North Carolina. The actual agency within DENR that is responsible for reviewing the application is the Land Quality Section of the Division of Land Resources. The applicant must notify adjacent landowners, local government officials, and other interested parties that he/she has filed a mining permit application with DENR. All parties have 30 days to prepare written comments and request a public hearing on the application.

Depending on public interest in the proposed project and the potential environmental impacts, DENR may schedule and conduct a public hearing. At the hearing, private citizens and groups may present their views and learn more about the proposed mining project. DENR staff evaluates the technical issues concerning the project as well as the public comments provided. Then the staff makes a recommendation to the Director of DENR's Division of Land Resources. The Director ultimately makes the final decision on the application. If mining is allowed, the company is given a permit that details the procedures and precautions it must follow to minimize environmental impacts from the project.

In North Carolina, there are seven conditions under which a mining permit can be denied:

1. The very nature of the operation violates the intent of the law. This would include a mining operation deemed negligent in some way.

2. There would be a significant adverse impact on endangered animal and plant species and on wildlife in general and/or on groundwater supplies used for drinking.

3. The operation would violate standards of air quality, surface water quality and groundwater quality.

4. How well the offsite impacts, such as blasting and landslides, are addressed by technology, buffer zones, berms and other means.

5. The operation would have a significant adverse impact on a publicly-owned park, forest or recreation area.

6. Impacts to offsite properties and water courses from erosion and sedimentation would be unacceptable.

7. The applicant has a record of violating environmental regulations.

Reclamation Phase

In the early days of mining, companies didn't think much about how the land would be used after the minerals were taken out of the ground. In the 1970s, laws were passed to protect the land and to require it to be returned to some useful purpose after mining. This is called **reclamation**. If reclamation is done right, people are protected from hazards like dangerous cliffs and deep ponds. The land is protected by requiring the soil to be returned and grass and trees to be planted. And, the air and water are protected by requiring mining companies to prevent pollution.

Some sites, mined before reclamation laws were passed, were left in poor condition. For example, some mining companies left steep cliff-like "highwalls" that were ugly and dangerous. They also left bare areas with no grass or trees. This resulted in runoff of sediments into streams, lakes and rivers. (Sedimentation kills aquatic plants and animals and gradually fills in bodies of water.) Sometimes the land would heal itself naturally, but not before environmental damage was done.

There are many uses for land that is reclaimed the correct way. Some of these uses are:

- ponds or small lakes that can be used for farming or fishing;
- fields for farming; pastures that animals can use for grazing;
- recreational areas such as golf courses, parks, playgrounds, and soccer fields;
- forests, wildlife areas or wetlands for birds and animals;
- large open areas for building houses, shopping malls, hospitals, prisons, airports, or other types of businesses.

There are many possibilities depending on the size and type of mine that is being reclaimed, the surrounding area, and the condition of the land.

The decision about what to do with the land involves lots of people: the mining company, DENR, the people who live near the mine, and the people from the nearby city or town who make decisions about what can be built in the area (town planners and zoning authorities, for example).

The most important part of reclamation is good planning. Miners must know how the land is going to be used after mining before they begin the mining process. This allows the miners to determine the best way to mine and protect the land at the same time. Miners work closely with the state government officials who write and enforce the laws and permits about how to mine and reclaim the land. The state makes the miners pay money before they begin mining (a reclamation bond) to make sure they do a good job. If a miner does a poor job or leaves without finishing his/her work, the state has the money to do the reclamation work itself.

There are many things that happen during mining that can cause environmental problems or make an area unhealthy of unsafe for people. Some of these things are dust, noise, vibrations, erosion and sedimentation. If the mining company starts reclaiming the land right away, even before it has finished mining other areas, some of these problems can be avoided. The sooner reclamation starts, the better it is for people and the environment. This is called **contemporaneous reclamation.**

When reclamation is done correctly, the miner will make sure that all of the different areas of the mine are reclaimed. This includes the following:

- Holes made to search for minerals (drilling holes) must be filled in. This will prevent water from filling the holes.
- Roads built by the miner to haul the materials out of the mine must be removed and fixed. The same thing must be done for any pipes or ditches that the miner used to help control water during mining.
- Equipment used for mining has to be removed. Sometimes the miner has to break up the equipment before moving it because it is so large. If the miner built any buildings, these would have to be torn down and removed too.
- Any pits that were left after taking the minerals out of the ground must be filled in or, if water is going to be left in them as part of the use of the land after mining, the miner has to be sure the ponds or lakes are safe. This sometimes means that the land must be sloped towards the lake or fences must be built around the pond or lake. It is also important to make sure the water is clean, especially if people are going to swim or fish in it.

After all of these things are done, the miner has to reclaim the land by doing several things. Some of these things are:

• At surface mines, where a lot of dirt was removed to reach the mineral deposits, this dirt (called **overburden**) may be placed back into the pit after the materials are removed. Then the dirt must be graded or smoothed out. After this is done, the miner may place topsoil on top of the overburden material so that grass and trees can grow.

• Usually, the topsoil has been saved from when the mine was first started and it is then put back. It is smoothed out so that the land looks like it did before mining. Sometimes the miner has to push dirt and topsoil up against any cliffs (highwalls) that the miner made during mining. This has to be done a little at a time so that the material stays in place and so that the cliff is eventually covered.

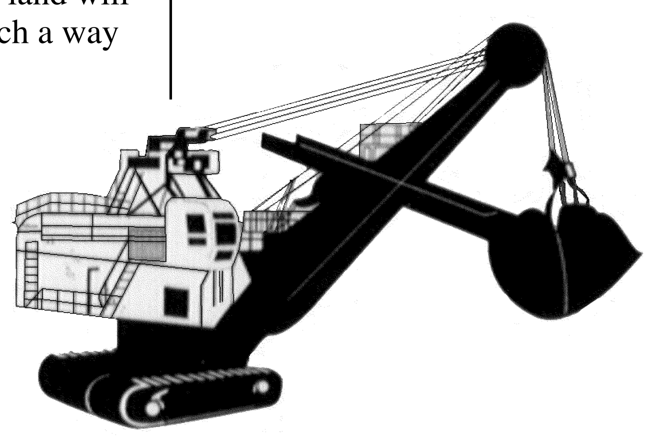
• After the land is put back into the right shape, the next step is to plant grass and possibly trees. This depends on how the land will be used. If it is going to be a pasture, hay or special grasses will be planted. If it is a farm, some type of crop like corn, soybeans, or wheat will be planted along with grass. If the land will be used for a shopping mall, a school or a hospital, regular grass will be planted to keep the topsoil in place until it is time to build. It all depends on the final land use.

• Once the grass and trees are planted, the miner must make sure that they stay healthy. He or she will fertilize the grass and will make sure the rain does not wash away the grass seed or the tree saplings. It is important to keep the grass and trees growing so that the topsoil is not washed away (erosion). Sometimes the miner might also build small dams to keep the water away from the newly planted areas. In a short time, the grass and trees will start to grow.

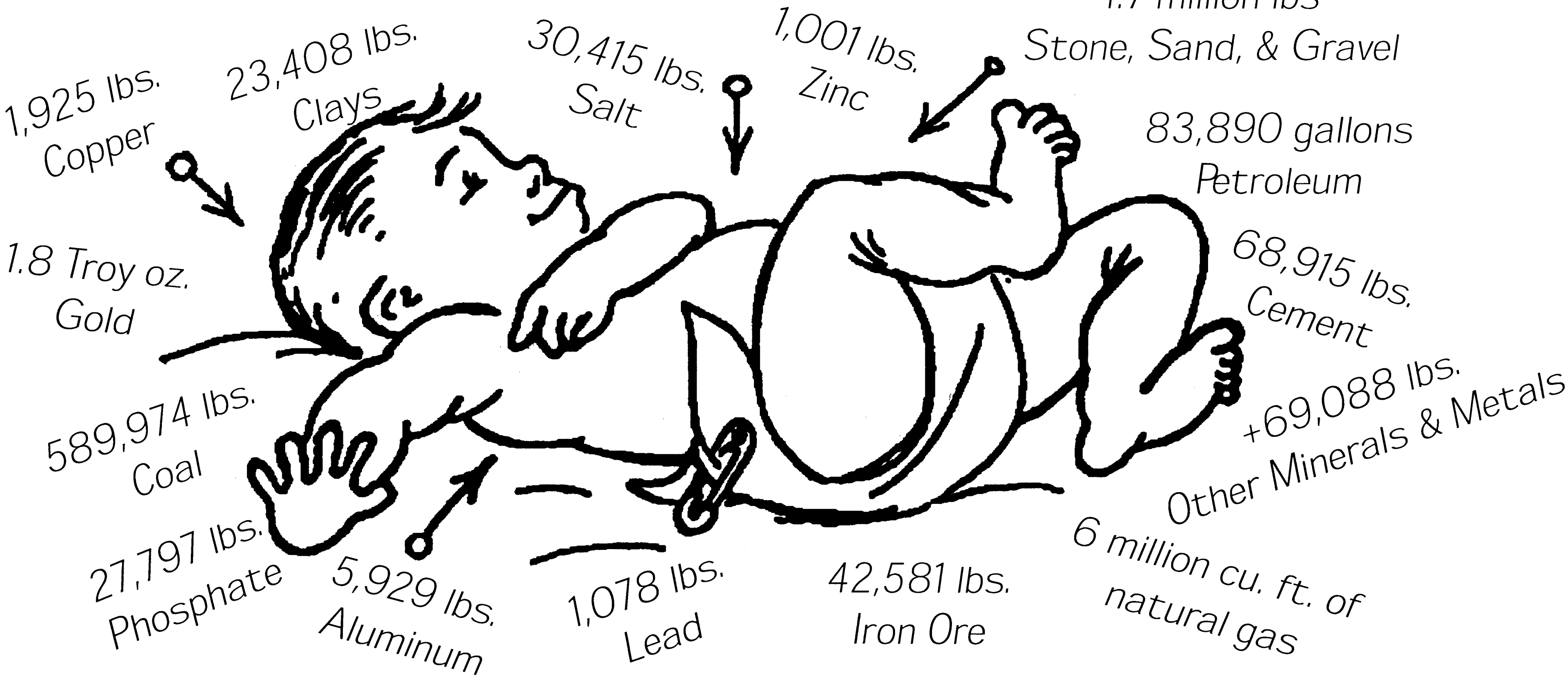
With successful reclamation, the area will look very much like it did before mining began. It will be in the same shape (hilly where it was hilly before, etc.). This is called **approximate original contour**. The reclaimed area will also have lots of grass, or other vegetation, depending on the post-mining land use.

Sometimes it is not practical to restore the land exactly as it was prior to mining. However, the land will be reclaimed in such a way that it conforms with the surrounding areas. There may be small ponds to collect rainwater in some instances. Efforts are made to make the area safe for animals and people and to prevent any environmental problems left over from mining.

Sometimes mining companies also help get rid of dangerous highwalls or other unreclaimed land problems that were left by miners from many years ago, before the reclamation laws existed. A mining company may go into those places and do more mining, then reclaim the land as described above. This is called **remining**. Remining results in unreclaimed land being returned to a beneficial use, and the area being made safe for people and animals once again.



Every American Born Will Need . . .



3¾ million pounds of minerals, metals, and fuels in a lifetime

Here are more examples of products that come from mines in North Carolina:

• Silica sand and quartz mined in North Carolina are used in the manufacture of glass. Refined silica sand is also used in the glass screens of televisions and computers and in electronic chips.

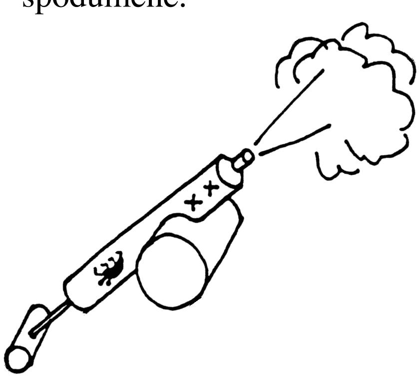
• Kaolin clay is used in the manufacture of dinnerware, fine porcelain and as a paper coating.

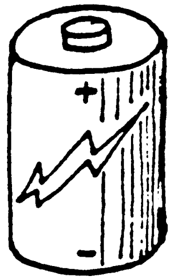
• Furnaces used to bake bricks are lined with olivine. Olivine is used as a refractory liner in kilns and heating furnaces. Olivine is mined in Yancey County.

• Peat is mixed with soil around plants and flowers. Peat is also used as an insulation for packing fruits and vegetables and as a protein additive in cattle food.

• Phosphate is used in plant food, fertilizers, animal feed, pesticides, ceramics and photographic chemicals.

• Lithium is produced from spodumene.



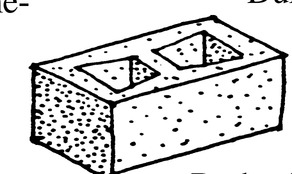


Lithium is used in supersonic aircraft, spacecraft, paints, batteries, grease, lubricants and medicine.

• Talc is used in paints, insecticides, rubber products, ceramics, paper coatings and dinner ware.

• Pyrophyllite is used in soap, bleaching powders and electric insulators. The most familiar use for both this mineral and talc is in talcum powder.

• Brick manufacturing is the third largest income-producing mining industry in North Carolina. Clay is mined and made into bricks of all shapes, colors and sizes. Bricks are also used for large buildings and in the paving of walkways. Some clays are made into drain and floor tiles.



• Many buildings, including the State Capitol, are covered by North Carolina dimension stone. One of the most popular is the Mt. Airy "granite." Dimension stone is also used to build monuments.

• Building stone is used to face or veneer buildings, walls and fireplaces.

• Emeralds, rubies, garnets and more than 300 other varieties of gemstones can be found in North Carolina. Thousands of tourists and rockhounds search for gemstones in North Carolina each year.

• North Carolina was once a major gold producing state. In 1799, a 17-pound nugget was discovered in Cabarrus County. That discovery touched off the first true gold rush in the United States. During the mid 1800s, gold coins were minted at the privately owned Bechtler Mint in Rutherford County and at a branch of the United States Mint in Charlotte. Although large-scale gold production ended in the 1800s, gold production continued until 1942. New mining technology has renewed interest in commercial gold production.

• The crushed rock, sand and gravel used to build roads and buildings comes from North Carolina's largest income-producing mining industry – **aggregate mining**. Without it, we could not build roads of concrete or asphalt or construct bridges.

VOCABULARY

Absolute dating - a technique used to date rocks based on the decay rate of radioactive elements in the rocks.

Acadian orogeny - a middle-Paleozoic mountain-building event.

Aggregate mining - the mining of uncrushed or crushed gravel, stone, rock or sand.

Alligator Back Formation - a mappable unit of rocks consisting primarily of gneiss, amphibolite, and minor amounts of quartzite and marble which are exposed along the Blue Ridge escarpment from Wilkes County, NC to Patrick County, VA.

Alluvial fan - a fan-shaped accumulation of sediment deposited at the mouth of a ravine.

Amphibole - a group of generally dark hydrous silicate minerals including common rock-forming varieties such as horneblende and actinolite.

Amphibolite - a type of dark metamorphic rock consisting mainly of amphibole and plagioclase feldspar with little or no quartz.

Approximate original contour - in mining reclamation, it is making the lay of the land much like it was prior to mining.

Biotite - a black, dark brown, or dark-green iron and magnesium-bearing mineral of the mica group.

Cascade - water flowing over and in contact with steep rocks.

Chemical weathering - the erosion or wearing down of a rock and its minerals by chemical reactions which change the identities of the minerals.

Clastic - a rock or sediment composed of fragments derived from pre-existing rocks or minerals and transported by wind, water, or ice.

Cleavage - the tendency of a mineral to break along well-defined planes of weakness.

Colluvial deposit - the mass of rocks at the bottom of a slope or cliff.

Compaction - the process or state of being pressed together; compacted.

Composite - a complex material in which two or more distinct components combine to produce a material unlike any of its components.

Contemporaneous reclamation - reclaiming a mining site while it is in the process of being mined.

Continental plates - granitic plates on which the continents ride. When these plates collide, they push up mountains and create metamorphic rock because of the pressure of the collision.

Crystal - a solid mass of mineral, having a crystalline structure: a regular geometric shape bounded by smooth, flat surface (crystal faces).

Decay - to decompose; rot.

Deposition - process by which materials, carried by the agents of erosion, are dropped elsewhere.

Differential weathering - weathering that occurs at different rates, as a result of variations in composition and resistance of a rock, or differences in intensity of weathering. It usually results in an uneven surface where more resistant material stands higher or protrudes above softer or less resistant parts.

Dike - a tabular igneous intrusion that cuts across the bedding or foliation of the surrounding rock.

Earth's crust - a rigid shell only about 30 miles thick, less than one hundredth of the distance to the earth's center. Eight elements account for almost 99% of the earth's crust: oxygen (46.7%), silicone (27.7%), aluminum (8.1%), iron (5.1%), calcium (3.7%), sodium (2.8%), potassium (2.6%) and magnesium (2.1%). Granitic material makes up continents; basaltic rock makes up oceans.

Element - a substance, such as oxygen, silicon or carbon, that cannot be split into smaller chemical substances.

Eon - the largest unit of geologic time. Earth's history is divided into four eons: Hadean, Archean, Proterozoic and Phanerozoic.

Epoch - a unit of geologic time that is a division of a period.

Era - a unit of geologic time made up of one or more periods.

Erosion - the process whereby water, wind and ice loosen and carry away rock debris. This process continually wears down all rocks, creating sediments which eventually form new sedimentary rocks.

Exfoliation - an erosional process in some rocks where parts of the rock flake or come off in layers parallel to the surface.

Exfoliation dome - a large, dome-shaped form developed in massive, uniform course-grained rocks by exfoliation.

Extrusive igneous rocks - rocks formed on the earth's surface by the cooling of molten magma material originating within the earth's crust. Once magma reaches the surface it is called lava.

Fault - a break in the earth's crust along which movement has occurred.

Feldspar - any of a group of abundant rock-forming minerals occurring principally in igneous, plutonic, and some metamorphic rocks and consisting of silicates of aluminum with potassium, sodium, calcium, and rarely barium.

Flail - a manual threshing device consisting of a long, wooden handle or staff and a shorter, free-swinging stick attached to one end. It was used to strike or beat grain to separate the grain from the rest of the plant.

Flourescence - the visible light given off by a mineral when it is exposed to (invisible) ultra-violet rays.

Folding - to bend over or double up so that one part lies on another part.

Foliation - in metamorphic rocks, the layered texture that results from parallel arrangement of flat or elongated mineral grains such as mica.

Fossils - the remains or indications of an organism that lived in the geologic past.

Fracture - the characteristic manner in which a mineral breaks.

Geologic process - the breaking down and building up of rocks, such as weathering, erosion, sedimentation and volcanic action; the phenomena of how the earth is formed.

Geologic time - all the time that has occurred since the formation of the earth.

Geologist - one who studies geology.

Geology - the scientific study of the origin, history and structure of the earth.

Gneiss - a foliated, metamorphic rock composed mainly of quartz and feldspar. This rock often has a striped or marbled appearance with light and dark minerals lining up in bands.

Gradient - the rate of incline or slope.

Granite - An intrusive igneous rock with very course grains composed of quartz, potassium feldspar and mica.

Granodiorite - a rock that is similar to granite but contains less potassium feldspar (orthoclase) and more sodium feldspar (plagioclase). Granodiorite may also contain more biotite, hornblende or other dark-colored minerals than granite does.

Hardness - the ability of one mineral to scratch, or be scratched by another mineral. The hardness of a specific mineral is described by Mohs Hardness Scale.

Hematite - a mineral composed of iron and oxygen. A principal source of iron. Hematite is the substance that gives clay its red color.

Hornblende - the most common mineral of the amphibole group. It is commonly black to dark green, and occurs in distinct monoclinic crystals or in columnar, fibrous, or granular forms.

Igneous rocks - rocks formed by the cooling of molten magma.

Inorganic - involving neither organic life nor the products of organic life.

Intrusive igneous rocks - molten igneous rocks that force their way into the surrounding rock and solidify below the earth's surface.

Joint - a planar break or crack in a rock, without displacement.

Knick point - an interruption or break in slope where the longitudinal profile of a stream or valley changes abruptly.

Lava - molten rock (magma) that is forced out of a volcano or out of cracks in the earth's crust and onto its surface.

Leaching - process by which water dissolves and carries away minerals.

Limestone - a sedimentary rock that consists mainly of calcium carbonate.

Luster - the way a mineral reflects light. Can be glassy, metallic, pearly or dull.

Magma - molten rock deep within the earth from which igneous rock is formed.

Mantle - in geology, the layer of the earth between the crust and the core.

Mass wasting - downward movement of rock fragments under the influence of gravity, without transport by or in another medium such as water or ice.

Mechanical weathering - the erosion or breakdown of rock into particles without changing the identities of the minerals in the rocks; water is the most important agent.

Metamorphic rocks - rocks that have changed both physically and chemically due to increases in pressure and temperature, and chemically active solutions.

Metamorphosis - a transformation, a marked change in appearance or condition.

Mica - a mineral family recognized by its ability to be split easily into characteristic thin sheets.

Microbe - a very small (microscopic) life form; microorganism.

Mineral - a solid, naturally-occurring blend of elements having a uniform chemical composition and a constant set of physical properties, including a crystalline shape.

Nutrient - something that provides food or nourishment.

Organic - of, pertaining to, or derived from living organisms.

Oscillator - a device that swings back and forth with a steady uninterrupted rhythm.

Outcrop - an area of exposed rock. Examples are road cuts, stream beds, quarries and naturally occurring rocky areas.

Overburden - the soil or rock that covers a mineral deposit or orebody.

Oxide - a binary compound of an element or radical with oxygen.

Pangaea - the name of a hypothetical continent that fragmented into several of the continents on earth today.

Parallel sheet joint - a break in a rock face that occurs parallel to the rock face. When overlying rock is removed by erosion, pressure is released and the outermost layers of the outcrop pull away from the main mass of rock.

Pavement outcrop - a large, relatively flat, exposed rock outcrop.

Pegmatite - an exceptionally course-grained, light-colored intrusive igneous rock, with interlocking crystals of quartz, feldspar, and mica, usually found as irregular dikes, lenses or veins, especially at the margins of large bodies of plutonic igneous rock.

Period - a unit of geologic time that is a division of an era.

Piezoelectricity - ability of some materials, such as quartz, to generate a small amount of electricity when squeezed or put under pressure.

Pluton - a large plutonic mass, at least partially igneous, that has more than 40 square miles (100 square kilometers) of surface exposure and no known floor.

Point bar - the sediment deposited on the inside of a meander in a stream.

Pyrite - a mineral, iron sulfide, $FeS_{2,}$ also called fool's gold. This brassy-yellow mineral consists of iron and sulfur.

Quartz - a hard crystalline mineral made of silicon dioxide, SiO_2.

Raw material - unprocessed natural products used in manufacturing.

Reclamation - the various methods, such as replacing top soil and reforestation, used to restore a mine site for beneficial uses upon completion of a mining operation.

Remining - going into a on old mining site that existed before reclamation laws existed, doing more mining, then reclaiming the land to return it to a safe area of that is of beneficial use.

Relative dating - a technique used to estimate the age of rocks based on their relative position in a sequence of rock units. Fossils, if available, are also used to estimate age.

Resistant rocks - Rocks or minerals that weather and erode more slowly than other rocks or minerals in the same area.

Resonator - a hollow chamber or cavity with dimensions chosen to permit internal resonant oscillation of electromagnetic or acoustical waves to specific frequencies.

Rock - a naturally-occurring consistent mass of one or more minerals; the three rock types are named according to their formation processes: sedimentary, metamorphic and igneous.

Rock cycle - the process whereby one rock type changes into another.

Rutile - a lustrous red, reddish-brown, or black natural mineral used as a gemstone, as a source of titanium, and in paints and fillers.

Sandstone - a sedimentary rock consisting of quartz sand particles or grains cemented together.

Schist - any of various medium to coarse-grained metamorphic rocks composed of laminated, often flaky, parallel layers of chiefly micaceous minerals.

Sediment - material that settles to the bottom of a liquid, such as soil being washed into a lake and settling to the bottom.

Sedimentary rock - bits and pieces of other kinds of rock that have been cemented together under pressure and deposited in layers near the earth's surface; sometimes containing the remains of once-living things (fossils).

Shale - a fine-grained sedimentary rock composed largely of clay, mud or silt and characterized by its tendency to split easily along parallel planes.

Silicate - any material containing silicon and oxygen.

Siltstone - a sedimentary rock composed of small, silt-sized rock or mineral particles.

Streak - the color left behind when the mineral is rubbed across the surface of a piece of unglazed, white porcelain.

Taconic orogeny - the earliest mountain-building episode in the Paleozoic era.

Tectonic plates - blocks of oceanic and continental crust and upper mantle, supported by a viscous underlayer of the lower mantle.

Vent - an exit hole for hot gases and lava to flow from a volcano.

Vertical fracture - a vertical break in a rock.

Volcanic eruption - a generally violent bursting forth of lava, volcanic ash and gases from a volcano's vent.

Volcano - a cone-shaped hill or mountain consisting chiefly of volcanic materials built up around a vent or hole in the earth's crust from which eruptions occur.

Watershed - all of the land area that drains directly or indirectly into a creek, river, lake or other body of water.

Wave stabilizer - a machine used to stabilize waves.

Weathering - the chemical alteration and/or mechanical breakdown of rock materials during exposure to air, moisture, and organic matter.

Weathering pit - a shallow depression on the flat or gently sloping summit of large exposures of granitic rocks, attributed to strongly localized solvent action of impounded water.

Xenolith - literally, a "stranger" rock. It was surrounded during the movement of magma to form an unrelated inclusion within the surrounding igneous rock.

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N.C. Division of Land Resources, Land Quality Section. For information on mining, the N.C. Mining Commission, and the state mining act, call (919) 733-4574. Web: http://www.dlr.enr.state.nc.us/mining.html

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SCHEDULING WORKSHEET

For office use only:
Date request received________________ Request received by_____________________________

1) Name of group (school) ____

2) Contact person ____________________________ ______________________________________
Name phone (work) (home)

____
Address

3) Day/date/time of requested program ____

4) Program desired and program length ____

5) Meeting place ____

6) Time of arrival at park ________________ Time of departure from park _______________

7) Number of students __________________ Age range (grade) ________________________
(Note: A maximum of 30 participants is recommended.)

8) Number of chaperones ________________
(Note: One adult for every 10 students is recommended.)

9) Areas of special emphasis ____

10) Special considerations of group (e.g. allergies, health concerns, physical limitations)_________
____

11) Have you or your group participated in park programs before? If yes, please indicate previous programs attended: ____
____

12) Are parental permission forms required? _________ If yes, please use the Parental Permission form on page 8.2.

I, ____________________________________, have read the entire Environmental Education Learning Experience and understand and agree to all the conditions within it.

Return to: Stone Mountain State Park Fax: (336) 957-3985
3042 Frank Parkway
Roaring Gap, NC 28668

PARENTAL PERMISSION FORM

Dear Parent:

Your child will soon be involved in an exciting learning adventure - an environmental education experience at **Stone Mountain State Park**. Studies have shown that such "hands-on" learning programs improve children's attitudes and performance in a broad range of school subjects.

In order to make your child's visit to "nature's classroom" as safe as possible we ask that you provide the following information and sign at the bottom. Please note that insects, poison ivy and other potential risks are a natural part of any outdoor setting. We advise that children bring appropriate clothing (long pants, rain gear, sturdy shoes) for their planned activities.

Child's name ____

Does your child:

- Have an allergy to bee stings or insect bites?_____________________________________
  If so, please have them bring their medication and stress that they, or the group leader, be able to administer it.

- Have other allergies? ____

- Have any other health problems we should be aware of?____________________________
  ____

- In case of an emergency, I give permission for my child to be treated by the attending physician. I understand that I would be notified as soon as possible.

____   __________________
Parent's signature   Date

Parent's name _____________________________________ Home phone _______________
(please print)   Work phone _______________

Family physician's name ________________________________ Phone ___________________

Alternate emergency contact

Name____ Phone____________________

NORTH CAROLINA PARKS & RECREATION
PROGRAM EVALUATION

Please take a few moments to evaluate the program(s) you received. This will help us improve our service to you in the future.

1. Program title(s) ______________________ Date ________

   Program leader(s) ______________________

2. What part of the program(s) did you find the most interesting and useful? ______________________

____

3. What part(s) did you find the least interesting and useful? ______________________

____

4. What can we do to improve the program(s)? ______________________

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5. General comments ______________________

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LEADERS OF SCHOOL GROUPS AND OTHER ORGANIZED YOUTH GROUPS PLEASE ANSWER THESE ADDITIONAL QUESTIONS:

6. Group (school) name ______________________

7. Did the program(s) meet the stated objectives or curriculum needs? ______________________

   If not, why? ______________________

Please return the completed form to park staff. Thank you.

Stone Mountain State Park
3042 Frank Parkway
Roaring Gap, NC 28668